

**“STUDY ON FUNCTIONAL OUTCOME OF LOWER  
THIRD TIBIAL INCLUDING DISTAL 1/3 AND DISTAL  
1/4 FRACTURE FIXATION WITH MEDIAL  
ANATOMICAL LOCKING COMPRESSION PLATE”**

*Dissertation submitted to*

**THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY**

*In partial fulfillment for the  
award of the degree of*

**M.S.DEGREE BRANCH – II  
ORTHOPAEDIC SURGERY**

Submitted by  
**Reg. No. 221212052**



**STANLEY MEDICAL COLLEGE,  
CHENNAI - 600 001**

**APRIL - 2015**

## **WORD OF GRATITUDE**

With deep reverence and profound gratitude I express my heart  
full thanks to

**Dr. R.SELVARAJ**  
**M.S. ORTHO, D.ORTHO, D.N.B. ORTHO**

**Professor & HOD**  
**Department of Orthopedics**  
**STANLEY MEDICAL COLLEGE AND GOVT. STANLEY HOSPITAL**  
**CHENNAI (TAMILNADU)**

For the stimulating training and Guidance he has given to me. He is one of that extinct species of human being who works for the betterment of the others. He has molded lives of many and I am one of them.

It has been my proud privilege to learn from such a gifted teacher and extraordinary surgeon who has infinite zeal for perfection and unbiased observation in everything he does. His appetite for excellence and his tireless efforts to infuse spirit in his students have been paramount. It was his incessant guidance, inspiration and perpetual encouragement that enabled me to finish this work.

**Dr. VIKAS GUPTA**

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Whose scholarly guidance, infinite favor, moral support has enabled me to complete this work successfully.

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**DR. VIKAS GUPTA**

## **VOTE OF THANKS**

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**M.S. ORTHO**

**Professor & unit chief**  
**Department of Orthopedics**  
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**Dr. VIKAS GUPTA**

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## **CASE PROFORMA**

### **CASE NO.**

NAME:

FATHER'S NAME:

AGE:

SEX:

I.P.NO:

WARD:

OCCUPATION:

ADDRESS:

CONTACT NO:

### **PARTICULARS OF INJURY**

Date of admission:

Date of anaesthesia assessment:

Date of surgery:

Date of discharge:

History:

Type of injury: closed / open

Side of injury: right / left

Mode of injury:

Associated injury :

Description of distal tibial fracture based on A.O. classification:

Preoperative treatment:

Details of operative procedure:

Post operative care:

### **Follow up**

Physiotherapy advised:

active toe movement

Isometric quadriceps exercises

Knee bending

Time of pop slab removal:

Time and day of ankle mobilization:

Time and day of weight bearing : partial weight bearing

Full weight bearing

<b>Movement of ankle joint</b>	<b>4<sup>th</sup> week</b>	<b>8<sup>th</sup> week</b>	<b>12<sup>th</sup> week</b>	<b>16<sup>th</sup> week</b>	<b>6 month</b>
Plantar flexion					
dorsiflexion					
eversion					
inversion					
Deformity (if any)					
Instability( if any)					
Complication 1. infection 2. wound break down 3.screw site infection 4.oedematous ankle 5.valgus/varus deformity 6.malunion/non-union 7. others					

## **DECLARATION BY CANDIDATE**

I, Dr. VIKAS GUPTA , hereby declare that this dissertation entitled “**STUDY ON FUNCTIONAL OUTCOME OF LOWER THIRD TIBIAL INCLUDING DISTAL 1/3 AND DISTAL 1/4 FRACTURE FIXATION WITH MEDIAL ANATOMICAL LOCKING COMPRESSION PLATE**” is a bonafide research work done by me **Dr. VIKAS GUPTA, Reg. No. 221212052** Under the guidance of **Dr.R.SELVARAJ, M.S.ORTHO, D. ORTHO, DNB ORTHO, PROFESSOR & HOD, DEPARTMENT OF ORTHOPAEDIC SURGERY, STANLEY MEDICAL COLLEGE & GOVT. STANLEY HOSPITAL, CHENNAI-01 ( TAMILNADU)** *In partial fulfillment for the award of the degree of M.S.DEGREE BRANCH – II ORTHOPAEDIC SURGERY*

**Date :**

**Station :**

**DR. VIKAS GUPTA**



## **CERTIFICATE BY INSTITUTION**

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Professor ad H.O.D,  
Department Of Orthopaedic Surgery,  
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Chennai-600001.

**Date:**  
**Station:**

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## **CERTIFICATE BY GUIDE**

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DATE

STATION

**DR.R. SELVARAJ**

## **CERTIFICATE BY CO-GUIDE**

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**DR.M.ANTONY VIMALRAJ**

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**DR. VIKAS GUPTA**

## **A WORD OF REVERENCE**

Words can never express my feelings of deep gratitude and reverence for my esteemed teacher

**DR. T. THOLGAPIAN**  
**Prof & Unit Chief ,**  
**Dept. of Orthopaedics ,**  
**STANLEY MEDICAL COLLEGE & GOVT. STANLEY**  
**HOSPITAL,**  
**CHENNAI, TAMILNADU,**

Who has always been a constant source of knowledge and inspiration to me.

**Dr. VIKAS GUPTA**

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## **ACKNOWLEDGEMENT**

I express my sincere and humble thanks to

**DR. AL.MEENAKSHI SUNDHARAM**

**M.D, D.A.,**

**DEAN & CONTROLLER,**

**STANLEY MEDICAL COLLEGE & GOVT. STANLEY**

**HOSPITAL,**

**CHENNAI, TAMILNADU.**

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I bow in reverence to my beloved father Shri Tikam Chand Gupta, Mother Mrs. Nirmal Gupta, whose pivotal role in accomplishing this uphill task will never be forgotten. Above all it is my solemn duty to acknowledge the co-operation of all who participated in this study.

**Dr. VIKAS GUPTA**



ஒப்புதல் படிவம்

திரு/திருமதி/செல்வி:

வயது:

முகவரி:

தொலைபேசி:

சிகிச்சை முறையின் பெயர்:

கீழே கையொப்பமிட்டுள்ள திரு/திருமதி/செல்வி \_\_\_\_\_ ஆகிய நான் மேலே குறிப்பிடப்பட்டுள்ள சிகிச்சை முறையினைப்பற்றி என்னுடைய வட்டார மொழியில் நன்கு விளக்கபட்டேன். மேற்குறிப்பட்டுள்ள சிகிச்சை முறையின் பக்கவிளைவுகள், ஆபத்துக்கள் போன்றவைகளை முழுமையாக அறிந்துள்ளேன். மேலும் இந்த குறிப்பிட்ட சிகிச்சை முறை எப்பொழுதும் வெற்றியாகவே முடியும் என்று கூறமுடியாது என்பதையும், இந்த சிகிச்சை முறை வெற்றிகரமான விளைவினை கொடுக்கும் என்ற உறுதியினை கொடுக்க முடியாது என்பதனையும் நன்கு அறிவேன்.

நான் இந்த சிகிச்சை முறை Dr. VIKAS GUPTA என்பவரால் செய்யப்படும் என்பதையும் அறிவேன்.

இந்த சிகிச்சை முறையின் போது ஏதாவது சிக்கல்கள் ஏற்படின், எத்தகைய தேவையான அவசரசிகிச்சையையும் எனது முன் அனுமதியின்றி அளிக்க எனது ஒப்புதலை அளிக்கின்றேன்.

நான் என்னை இந்த ஆய்வில் ஈடுபடுத்திக்கொள்ளவும், என்னை புகைபடம் எடுப்பதற்கும் சம்மதம் அளிக்கின்றேன்.

மேலும் இந்த படிவத்தில் கொடுக்கப்பட்டுள்ள விவரங்களை நன்கு படித்து உணர்ந்து கொண்டேன் என்றும், இந்த குறிப்பிட்ட சிகிச்சை முறையினையும் அதிலுள்ள ஆபத்துகளையும் நன்கு அறிந்து எனது முழு சுய உணர்வுடன் இந்த எழுத்து பூர்வமான ஒப்புதலை அளிக்கின்றேன்.

நோயாளியின் பெயர்/பெருவிரல் ரேகை:

சாட்சி:

பெயர்:

தேதி:

கையொப்பம்:

INSTITUTIONAL ETHICAL COMMITTEE,  
STANLEY MEDICAL COLLEGE, CHENNAI-1

Title of the Work : Study on functional outcome of lower third tibial  
(Including distal 1/3 and distal 1/4) fracture fixation with  
locking compression plate.

Principal Investigator : Dr. Vikas Gupta,

Designation : PG in MS (Ortho)

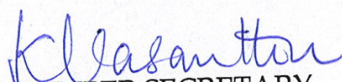
Department : Department of Orthopaedics  
Government Stanley Medical College,  
Chennai-01

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 01.04.2014 at the Council Hall, Stanley Medical College, Chennai-1 at 2PM

The members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The Principal investigator and their team are directed to adhere to the guidelines given below:

1. You should inform the IEC in case of changes in study procedure, site investigator investigation or guide or any other changes.
2. You should not deviate from the area of the work for which you applied for ethical clearance.
3. You should inform the IEC immediately, in case of any adverse events or serious adverse reaction.
4. You should abide to the rules and regulation of the institution(s).
5. You should complete the work within the specified period and if any extension of time is required, you should apply for permission again and do the work.
6. You should submit the summary of the work to the ethical committee on completion of the work.

  
MEMBER SECRETARY,  
IEC, SMC, CHENNAI

## INTRODUCTION

Fracture of lower third of tibia including distal  $\frac{1}{3}$  and distal  $\frac{1}{4}$  are primarily located within distal tibia in a square shape wide region ,fracture in pattern with comminution extension or non comminution. Treatment in age group 30 to 60 years of these fractures is very difficult and problematic. The various factors that affect the end result outcome are as following-

1. Fracture pattern and type,
2. Trauma to soft tissue associated with fracture,
3. The modality and method of fracture management and caliber of reduction,

Forces which are responsible for lower third fractures of tibia bone.

1. Axial compression forces with high grade and high velocity,
2. Torsion and bending due to direct trauma forces
3. Low energy rotation forces.

Among all tibial fractures these distal tibial fractures constitute less than 7% and less than 10% of all lower extremity fractures. Fracture of lower third region of tibia is very common in males: 30-40 years age

group and mostly due to road traffic accident, falls from height or twisting injuries of ankle while getting stop from a motive phase.

Distal tibia fracture has certain features which make this fracture more prone to end up in complications.

These are:

1. Distal part of tibia is weight bearing and locomotive system ,
2. Its inherent instability,
3. Bone is subcutaneous in whole extent with minimal soft tissue cover,
4. Often comminuted,
5. Blood supply in distal fourth is poor.
6. Fracture is often associated with breach of soft tissue,
7. Salvage procedure have high failure rates.

Fractures of distal tibia involve a major weight loading surface, which is likely to cause a functional impairment later on.

To preserve ankle function, surgeon has to follow some important considerations which are preserve and maintain joint congruity,

1. preserve normal axial biomechanics of knee and ankle joint,

2. Preserve the joint articulation and functioning ,
3. Preserve a near normal arc of motion of the joint.

This is difficult to accomplish all above mentioned important considerations in each and every case as we face,

- 1, compromised soft tissue condition,
- 2, variable bone quality and
- 3 associated medical conditions.

Un-displaced and minimally displaced fractures can be managed by non operative methods with

1. Mild acceptable mal union with negligible shortening,
2. Mild and negligible limb discrepancy of the affected leg,
3. Minimal restriction of arc of motion of the affected joint
4. intra-articular fracture of distal tibia (pilon fracture) , if treated with non operative management presents with early development of ankle joint osteoarthritis

Operative management of lower third tibial fractures can be complicate and difficult hence pre operative planning for management is mandatory. Pre operative assessment of Type and pattern with classification of the fracture, assessment of grade of soft tissue trauma, and availability of bone stock and quality of bone imperatively decides the operative techniques of fixation. Various operative methods have been available including external fixation, fixation by interlocking intramedullary nailing, and osteosynthesis by plating.

External fixation is indicated in compound fractures with violence of soft tissue. (Fixation with Nailing and plating are contraindicated in acute setting of compound fracture) . Fixation of distal tibial fracture with external methods by A O external fixators may cause improper reduction and flexible, unstable reduction which results predispose for mal-alignment of high grade (range, 6%–28%) or nonunion (range, 2%–17.6%) , and shanze screw site infection (range, 10%– 100%).

In case of diaphyseal and middle region of tibia , fracture can be well fix and stabilize with intramedullary interlocking nailing. Intramedullary nailing advantages of maintenance of vascularity at fractured site and soft tissue environment. Distal lower end of tibia is widened corresponding to the middle diaphyseal region .Tibia starts to Splay

widened at distal end as intramedullary region forms hourglass shape. In this widened canal region stable and close fit intramedullary nailing cannot be achieved because hourglass shape interferes with close packed endosteal fitting which ultimately interferes with angular and torsional stable fixation. Some complications associated with intramedullary nailing are

1. Fracture displacement can be increased while insertion and advancement of nail,
2. Screw pull out and loosening of locking screws (range, 5%–59%), and
3. Bending of nail ( 1-2%)
4. Misalignment of the tibia (range, 0–25%)
5. In case of distal  $\frac{1}{4}$  tibial fracture locking with two medial to lateral screw is somewhat difficult.

Encouraging results for open reduction and internal fixation with plating and closed manual reduction with osteosynthesis by minimal invasive percutaneous precontoured dynamic compression plates have been noted for lower third tibial fracture.

At present management of complicated lower third fractures has been overcome by the meaning of locking compression plate.

Locking compression plate allows locking of screw's threaded head to lock to the plate, thereby constructing a rigid, stable, and fixed-angle device. A locking plate provide a superior grade and higher degree of stability in place of conventional plate and impart superior protection without loss of any primary and secondary reduction and minimal contact with bone. Locking compression plating can be done with both open and percutaneous method.

Advantages of distal tibial locking plate:

### **1. Provides Anatomic reduction**

Locking compression plates are precontoured anatomical plate which assists reduction of metaphysis to diaphysis and imparts proper alignment of the articular congruity.

### **2. Provides Stable fixation**

In locking compression plate, fixed angled construct forms by locking screws as threaded head portion of locking screw closely locked with threaded hole of locking compression plate



### **3. Preservation of blood supply**

Locking compression plate has tapered end which allows sub muscular plate insertion. Sub muscular plate insertion allows minimal dissection of soft tissue cause minimal soft tissue injury which preserve soft tissue viability.

Minimal periosteal dissection preserves the blood supply of comminuted fragments.

Locking compression plate has limited-contact plate design which reduces plate-to-bone contact. Minimal contact between plate and bone limits implant induced vascular trauma and vascular insult of bone.

### **4. Prevent joint stiffness.**

Locking compression plate construct and designed with AO technique hence provides an early bone healing, early mobilization of joint expediting a return to optimal function without stiffness.

Locking compression plate can be applied both open and minimal surgical techniques. Both open and minimal surgical techniques in lower third tibia fractures are practicable. Locking compression plate by open method can be used for distal 1/3 tibial fracture which are less comminuted, displaced fracture not involving tibial plafond, fracture too

far at lower level which cannot be managed by intramedullary interlocking nailing.

Minimal invasive method for locking compression plate may be advantageous in that it causes less soft tissue injuries and preserves the vascularization of the fracture site. Indications for minimally invasive plate osteo-synthesis of lower third fractures include widely separated tibial plafond, comminuted lower third tibial fracture, and fracture which are far away for proper fixation with intramedullary nails.

## **AIMS AND OBJECTIVE**

Therefore this study included use of locking compression plate for distal tibial fracture by both open and minimal invasive method to assess the,

1. Rate of union, any deformation in ankle, leg length differences and gait, arc of motion of ankle, return to previous daily and sports, routine activities, infections and other consequences associated with distal tibial plates and to compare the results achieved by other researches to evaluate whether these plates are suitable devices for operative treatment of lower 1/3 tibial fractures.
2. To assess the arc of motion ankle, any deformation in ankle, walking habits and gait analysis ,rate of fracture union, return to previous routine and sports activities in case of lower third tibia locking plate used for distal 1/4 tibial fractures.
3. To describe any complications in treating lower third tibial fracture with LCP both open and minimal method.
4. To evaluate the function outcome of lower third tibial fracture fixation with LCP.

## **REVIEW OF LITERATURE**

Lower third tibia fractures are primarily located at widened distal region which include both extra articular and intra articular fracture. Intra articular fracture of distal tibia is known as pilon fracture.

In 1911 Desot described the term “Tibial pilon” fracture to explain these compression injuries. French word ‘Plafond’ (ceiling) to refer the horizontal distal tibial articular surface was used by Bonin.

Tibia is major weight bearing bone of the leg. Distal third of tibia is particularly prone for delayed and non union because of its precarious blood supply. Distal tibial metaphyseal fracture of arbeitsgemeinschaft fur osteosynthesefragen ( A O) type 43A1, 43A2, and 43A3 are difficult to treat and pose significant challenge to most orthopaedic surgeons. Most of these fractures are associated with fracture displacement, comminution, and injury to soft tissue envelop.

Initially in 19<sup>th</sup> century manual reduction by closed methods and immobilization with plaster was the management for these type of injuries and again between 1910 and the 1960 (Weber 1967, Bohler 1951, Lambotte 1913).Before 1970 distal tibia extra articular fracture

treated by long above knee slab, cast conversion for 4 to 6 week, followed by functional bracing or patellar tendon bearing cast.

This method continues to be used, but acceptable result comes in only un-displaced fractures. Conservative management of distal tibia fracture usually complicate as in a number of mal-alignment, stiffness of ankle and non union.

**Calcaneal pin traction** was introduced by **Bohler** <sup>[1]</sup> and colleagues as a technique in the treatment of distal tibial fracture with successful improvement in closed reduction technique with pin traction. Followed by below knee plaster immobilization ( Bohler 1951). Later preference operative management considers superior to conservative management emerges around the turn of century.

**Lambotte's**<sup>[2]</sup> surgical management was widely accepted and attempted by many were French surgeons to improvise their results, Due to infection, sepsis many of them failed to get good result and at the end result in amputation operative fixation was deferred until 1960.,

**Gay and Evrard (Gay 1963)**<sup>[3]</sup> were successful first time to get surgical stabilization of whole lower third tibia fracture. They recommended surgical fixation of fracture in simple displaced fracture

with minimal number of large fragments.1960 AO-ASIF group recommended that secondary osteoarthritis in lower end of tibial fracture can prevent by only meaning of operative methods with proper anatomical reduction and rigid stable fixation. They also suggested early start of mobilization exercises prevents ankle stiffness. Their concepts also accepted for management of difficult pilon fracture,

In a study of 84 patients conducted by **Ruedi TP et al**,<sup>[4]</sup> that established the open reduction and internal fixation with screws and plate as the standard, the authors with a nine year follow up reported 74% good functional results. The principles of treatment included

1. Re-establishment of the fibular length
2. Re-construction of the articular incongruity of distal tibia
3. Placement of metaphyseal cancellous graft; and
4. Stabilization of the medial aspect of tibia using a plate.

Of the 84 fractures, 60 were secondary to low energy skiing injuries. 90% of the patients returned to their previous activities.

In a series of 26 patients by **Kellam J et al**,<sup>[5]</sup> patients were divided into 2 groups based on fracture pattern. Type A fractures with twisting injuries with little comminution, whereas Type B fractures were

more severe injuries, with a crush component. On treatment with open reduction and internal fixation, 65% cases had good to excellent results. Better results were obtained in Type A fractures (84%) than B (53%). Crucial factors besides fracture type were the length of immobilization and quality of reduction. Prolonged immobilization resulted in poor outcome, showing the need for stable fixation to permit early motion at the joint.

In a retrospective clinical review by **Bourne R et al**,<sup>[6]</sup> 42 patients treated with open reduction and internal fixation demonstrated the importance of using a logical classification system in describing the outcome of fractures of the distal tibia. The results of this study have clearly demonstrated that Types I and II (Ruedi and Allgower) are amenable to open reduction and stable internal fixation with an 80% success rate. The Type III fractures present a much more difficult problem; a satisfactory outcome was present only in 6 of the 19 patients (32%) in this study.

A high energy pattern correlated with a higher incidence of wound healing complications. This inference was obtained in a large series of patients (145) by **Ovadia DN et al**<sup>[7]</sup> in which 46% were high energy injuries. Eighty patients underwent open reduction and rigid

internal fixation whereas others underwent other procedures like closed reduction and cast (32), calcaneal pins and plaster (8), fibular stabilization and cast (3), internal fixation and external fixation (5). They had 34 fractures equivalent to Ruedi and Allgower Type III and good to excellent results were achieved only in 47% of the patients.

A series **Dillin L et al reported** <sup>[8]</sup> disastrous results when inadequate and unstable fixation was used to treat the distal tibial fractures. They had 36% rate of skin sloughing and a 55% infection rate.

**Wyrsh B et al** <sup>[9]</sup> conducted a randomized prospective study involving two groups of patients, one (18) who underwent surgical management with ORIF and the other group (20) who underwent external fixation, showed no remarkable changes in clinical scores. However, because of some specific complications in the reduction of fracture by open techniques and internal fixation group, with no remarkable results in final outcome, their suggestion was described as limited fixation with external methods and open with internal fixation are equally same.

Follow up evaluations of 34 distal tibial fractures by **Helfet DL et al** <sup>[10]</sup> showed that results of surgical management are mainly affected by on the status of initial injury, the quality and stability of the reduction.



The pattern of injury, severity of comminution, and loss of articular incongruity affect the final outcome. 65.4% of Type II fractures had excellent results, 11.5% adequate and 23.1% had poor results. In Type III fractures, only 20% had excellent, 12.5% adequate and 37.5% poor results.

In a study of 30 patients by **Im GI et al**<sup>[11]</sup> using anatomic plates and screws, open reduction and internal fixation was done with 88.2% excellent to good results according to Oleurd and Mollander function ankle score and with a better alignment of fracture fragments.

**Hazarika S et al**<sup>[12]</sup> conducted a study on 20 patients of distal tibial fracture treated using locking compression plates through MIPPO technique. This approach decreases the soft tissue handling and maintains the vascularity in great extent. This provides 87.5% of good to excellent result. Fracture were classified according to the AO system and performed as scored stage surgery after sterilization with external fixator primarily.

In a study by **Gao H et al**<sup>[13]</sup> 32 adult patients of metaphyseal distal end of lower tibia operated with poly axial locking screw system.. The polyaxial locking system shown results of 87.3 functional out come with American Orthopaedic Foot and Ankle Society score provides

more surgical modality, with a successful mode of treatment for short distal metaphyseal fractures of lower tibia.

In a study by **Ozakaya U et al**,<sup>[14]</sup> 22 patients with lower third tibial fractures were operated and fixed with titanium locking compression plates using minimally invasive technique good biological fixation of distal tibial. A total of 81% of good to excellent outcome was assessed using American Orthopaedic Foot and Ankle Society.

**Ahmad MA et al**<sup>[15]</sup> conducted a study on lower tibial fractures fixed with lower tibial medial anatomical locking plates and resulted that lower tibial plate's causes fracture union with high rates, negotiable soft tissue consequences and acceptable better function results.

**Leonidou, et al**<sup>[16]</sup> found in their study that locking plate fixation of tibia fractures is technically demanding and achieves good results. Factors shown to predispose to infective complications are timing of surgery, high energy injuries and soft tissue status.

**R. Schouten et al**<sup>[17]</sup> studied 85 patients. Superficial infection occurred in 6 patients (7%) and deep infections in 4 cases (4.7%). There was only case of plate failure. 4 patients, including this case, required

further surgery to achieve union. There was high rate of metal ware symptoms that prompted plate removal.

**Collinge C. et al<sup>[18]</sup>** found in their study that minimally invasive medial plating of lower third tibial fracture maintain limb alignment with a 5% re-fixation rate and achieve mostly good-excellent (AOFAS)ankle scores.

**Bahari S, et al<sup>[19]</sup>** reported satisfactory outcomes with the use of the AO distal tibia locking plate in treatment of severely displaced lower tibial fractures. 89% of the patients treated with feeling of pre injury status and 95% returned to normal routine activities. Average union time was 22.4 weeks. Good alignment without any angulations achieved in all cases. Superficial infection noticed in 3 cases and deep infection found in 1 case. Average AOFAS score was 90 for all cases.

**Vallier noticed <sup>[20]</sup>** notices and given the result that diaphyseal fracture of lower third of tibia complicate as more angulations and malalignment if treated with intramedullary nailing instead of osteosynthesis by locking plate (22 patients v/s 2 patients,  $p=0.003$ ).

**Cheng**<sup>[21]</sup> **did** a small study on two groups min 15 pt in each groups. In one group patients operated with MIPO technique, in other group patients operated with open method. Result found better in MIPO and he got union in MIPO average 16.8 weeks and in open method union was 19.1 week

**Lau**<sup>[22]</sup> did a study in MIPO group patients in which late infection occurs around near 1 month after surgery. He told that there is no effect on union time if late infection occur in patients .rate of infection varies with 2.5 to 15 % and depend on the sample means compound fractures were considered in the study sample or not.

**Shrestha**<sup>[23]</sup> did a study based on osteosynthesis of lower third tibial fracture with minimal incision technique and got favorable results according to him LCP by MIPPO technique is highly effective surgical technique for lower third tibial fracture with high rate of union and low rate of complication. He found skin irritation by hardware prominence was common problem in study group.

## **SURGICAL ANATOMY:<sup>[24]</sup>**

The tibia is the medial and larger bone of the leg. It is a major weight bearing bone of the leg.

The tibia is divided into three parts:

1. Upper end – articulate with distal femur to form knee joint.
2. Triangular – diaphysis or shaft.
3. Lower end – articulates with fibula and talus to form ankle joint.

Lower end of tibia develops from single centre of ossification which appears approximately 2<sup>nd</sup> year of life and joins with shaft at 18 years of age.

In comparison of upper end, distal end of tibia contains smaller in size with 5 surfaces. Lower end of distal tibia elongated as a medial projection called as medial malleoli.

### **SURFACES OF LOWER END TIBIA:**

**Inferior Surface** is a quadrilateral and smooth for talo- tibial articulation. It forms a concave shape from before backwards, becomes

wider in front than back and passes from before backwards because of a elevation which separating two depressions..

It is continuous with that on the medial malleolus.

**Anterior surface** extensor tendon bounds anterior surface which is round and smooth at above, . There is a rough transverse depression at its distal margin for attachment of capsule of ankle joint..

**Posterior surface** there is a groove on posterior surface which is shallow and lays obliquely and downwards medial ward and serves as a pathway for tendon of flexor hallucis longus muscle.

**Lateral surface** there is a triangular rough depression for attachment of interosseous ligament which attaches tibia to fibula. Lower end of lateral surface becomes smooth and join with fibula. There is two prominent borders on lateral surface corresponding anterior and posterior for the attachment of anterior and posterior ligaments of lateral malleoli

**Medial surface** is elongated below and form a strong pyramidal process, anterior border of medial surface give attachment to the anterior deltoid ligament fiber and posterior border of medial surface gives passage to tendon of tibialis posterior and flexor hallucis longus.

Its posterior border presents a broad groove which lodges the tendons of the tibialis posterior and flexor digitorum longus. The summit of medial malleolus gives attachment to deltoid ligament.

Lateral surface of pyramidal process articulate with talus to form tibio-talar and medial surface of pyramidal process is smooth and become flat lies inward to medial malleoli.

The fibula is the lateral and smaller bone of the leg. It divided into:-

- Upper end
- Shaft
- Lower end
  - Lower end of fibula is a pyramidal shaped, somewhat flattened from side to side.
  - Lateral surface is convex and subcutaneous.
  - Medial surface is smooth, triangular and articulates with talus.
  - Anterior border is rough and thick and give attachment to anterior talo-fibular ligament.
  - Posterior border is broad having sulcus for passes of the tendon of peroneal muscle.
  - Summit is rounded and gives attachment to calcaneo-fibular ligament.

## **Relation of the lower end Tibia – Fibula:**

### **A. Ligaments:**

**a. Deltoid ligament:** Strong, flat, triangular band composed of a superficial and deep set of fibers.

**i. Superficial fiber** passes medial malleolus to navicular, sustentaculum tali of calcaneum and medial tubercle of talus.

**ii. Deep posterior talo-tibial ligament** passes medial malleolus to non articular surface of talus. This is the main stabilizer of ankle articulation..

**iii. Distal tibiofibular ligaments** from distal tibia to distal fibula

1. Anterior tibio fibular ligament

2. Posterior tibio fibular ligament

3. Strong interosseous tibiofibular ligament

### **b. Lateral ligament:**

1. Anterior talofibular ligament – Shortest and passes from anterior border of lateral malleoli to talus.

2. Posterior talofibular ligament- Strongest, passes from lateral malleoli to talus.



3. Calcaneo fibular ligament – Longest, passes from tip of lateral malleoli to calcaneum.

**B. Structure anterior to ankle joint:**

**a. Muscles:**

- i. Peroneus tertius
- ii. Extensor hallucis longus and brevis
- iii. Tibialis anterior
- iv. Extensor digitorum longus

**b. Vessels:** Anterior tibial artery and vein

**c. Nerve:** Deep peroneal nerve

**C. Structure posterior to ankle joint**

a. Superficial posterior compartment

b. Tendo-achilles formed by confluence of soleus and gastrocnemius tendon and their sheath.

c. Deep posterior compartment

d. Muscle:

- i. Tibialis posterior
- ii. Flexor digitorum longus
- iii. Flexor 5 posterior tibial artery and vein

e. Nerve – Tibial nerve

#### **D. Structure lateral to ankle joint**

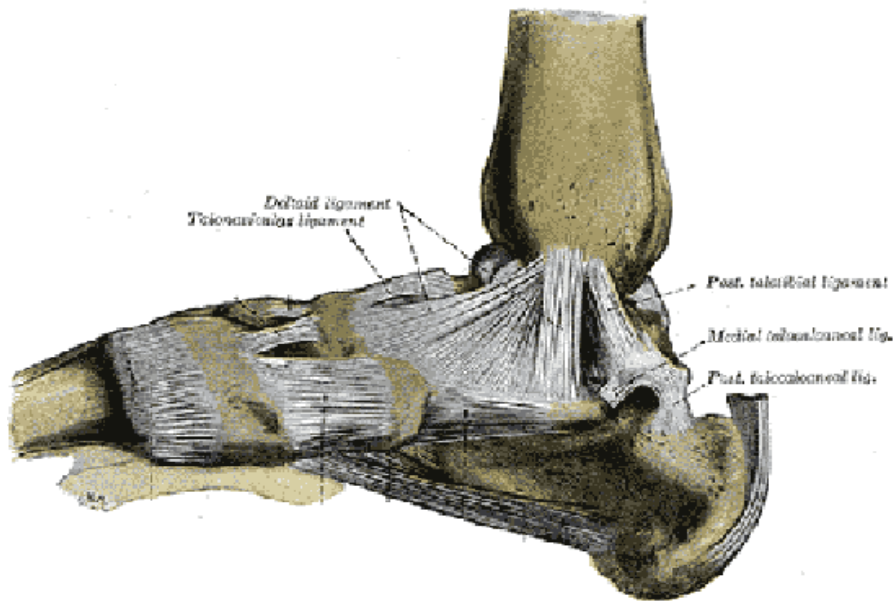
- a. Muscle:** Peroneus longus and Peroneus brevis muscle
- b. Nerve:** Superficial peroneal nerve

#### **Blood supply of Tibia:**

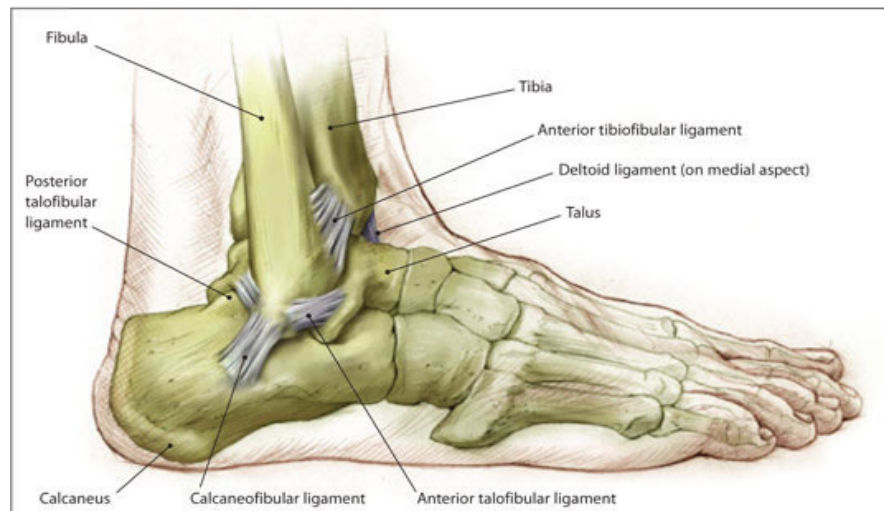
There are three main systems:

- 1. Nutrient artery:** - posterior tibial artery gives a branch to distal tibial region work as nutrient artery for tibia which enters the bone on its posterior surface. It is the largest nutrient artery in the body.
- 2. Metaphyseal – Epiphyseal arteries** – these enters bone by piercing in the region of the capsular ligament and then pass to metaphysis where they give multiple branches which end into a continuous arcade, which sends off branches and pierce the bone plate that act as a ceiling to epiphyseal cartilage.

**Periosteal arteries** – These form a continuous vascular layer around tibia. As these vessels passes close to the surface they give off many branches.

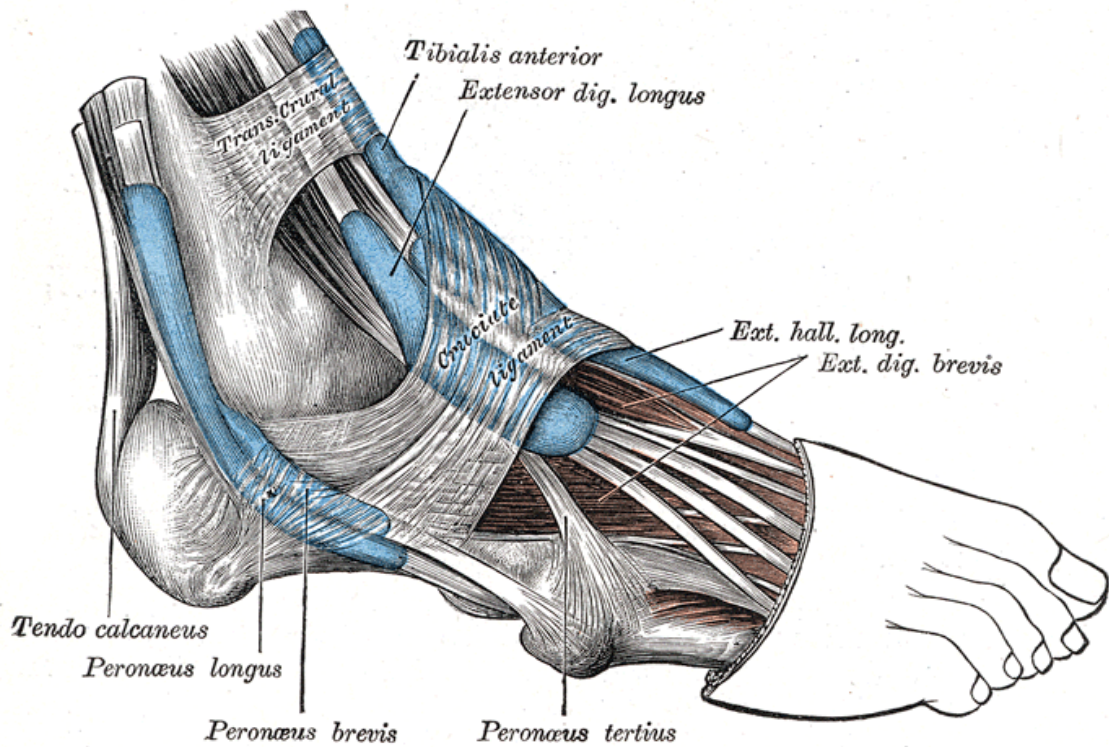
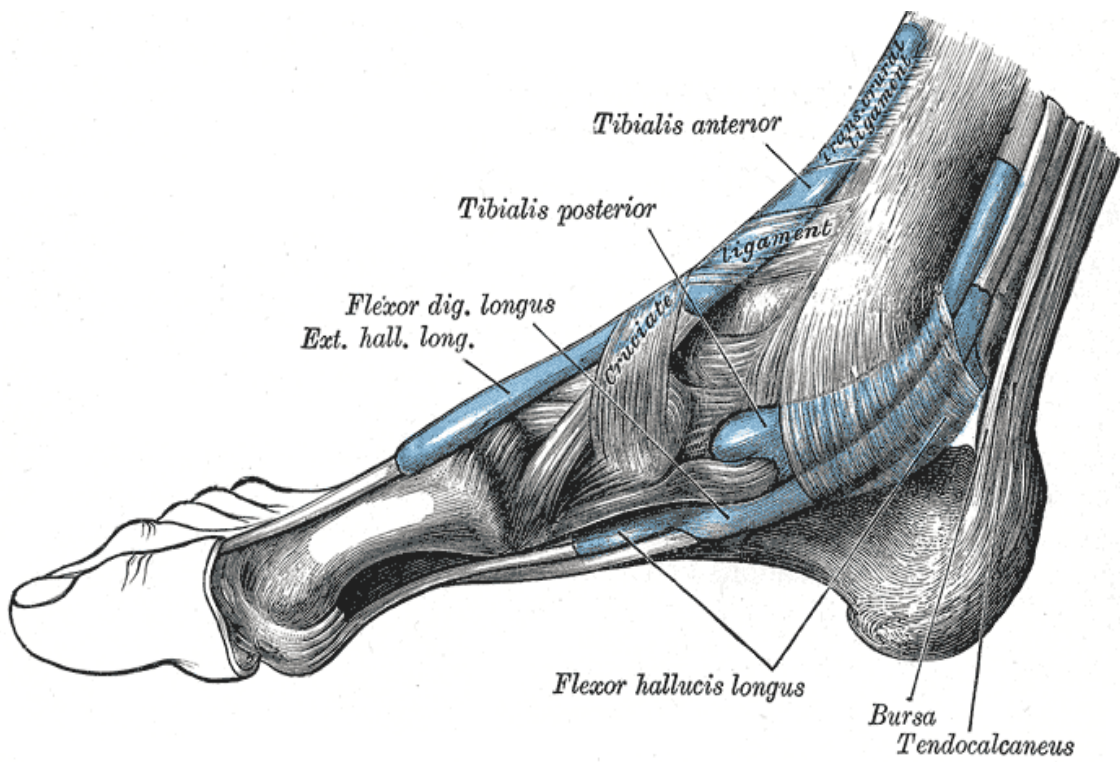


## DELTOID LIGAMENT



## LATERAL LIGAMENT

## STRUCTURES PASSING AROUND ANKLE JOINT



## CLASSIFICATION

Classification of any fracture is necessary for:

1. Documentation purpose.
2. It helps in communication.
3. It helps in deciding the line of management.
4. Comparing the results of various modalities of treatment.

An ideal classification of fracture takes into accounts its etiology and morphology.

These fractures have been classified as follows:

❖ **AO-OTA system** <sup>[25]</sup>: is a comprehensive classification scheme incorporating all fracture of the distal tibia both intraarticular and extra articular variety. The distal tibia is assigned a numeric code of 43.

Injuries of distal tibia are then categorized in 3 types and their further subdivision in to three groups and their sub groups are arranged in an ascending order of fracture comminution.

These sub groups are further divided into their subgroups by characteristics of their fracture:

The 3 types are labeled A, B and C.

❖ Type A- Extra-articular fracture

- i. A1-Simple
- ii. A2- Comminuted
- iii. A3- Severely comminuted

❖ Type B- Partial articular fracture

- i. B1- Including a portion of column
- ii. B2- Involving entire column
- iii. B3- Primary fracture in coronal plane creating a posterior malleolar fragment.

❖ Type C - Involve both metaphyseal surface and articular surface

- i. C1- without comminution
- ii. C2- without metaphyseal comminution and a simple articular surface.

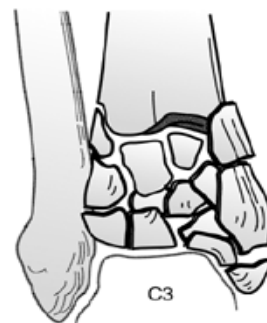
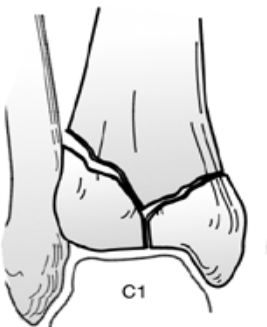
**C3-with metaphyseal comminution and a simple/complex  
articulate surface**



Type A - Extraarticular

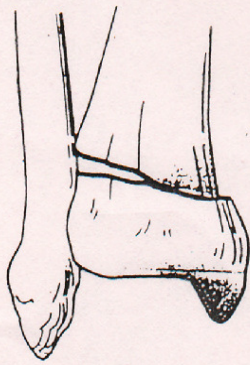


Type B - Partial articular



Type C - Total articular





A1

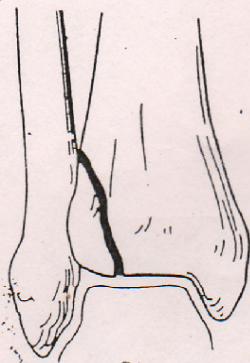


A2

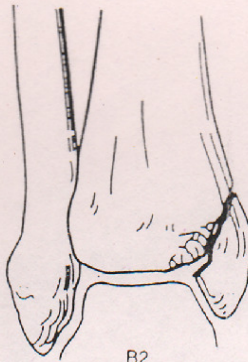


A3

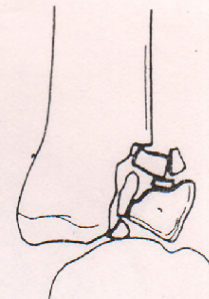
Type A - Extraarticular



B1

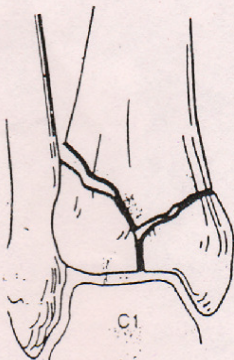


B2

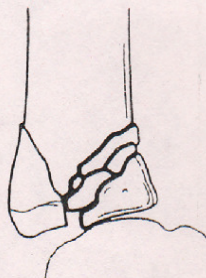


B3

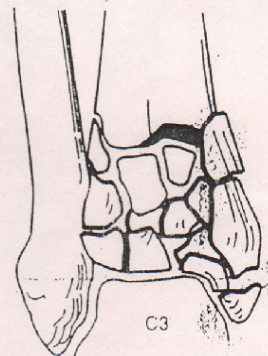
Type B - Partial articular



C1



C2



C3

Type C - Total articular

The three types and nine group of the AO/OTA classification of distal tibia fractures are illustrated. The three types of fractures are extra-articular, partial articular and total articular and they are divided into nine groups based on the amount of comminution, as shown.



## **Ruedi and allgower classification for plafond fracture<sup>[26]</sup>**

This classification based on severity of comminution and the displacement of the articular surface.

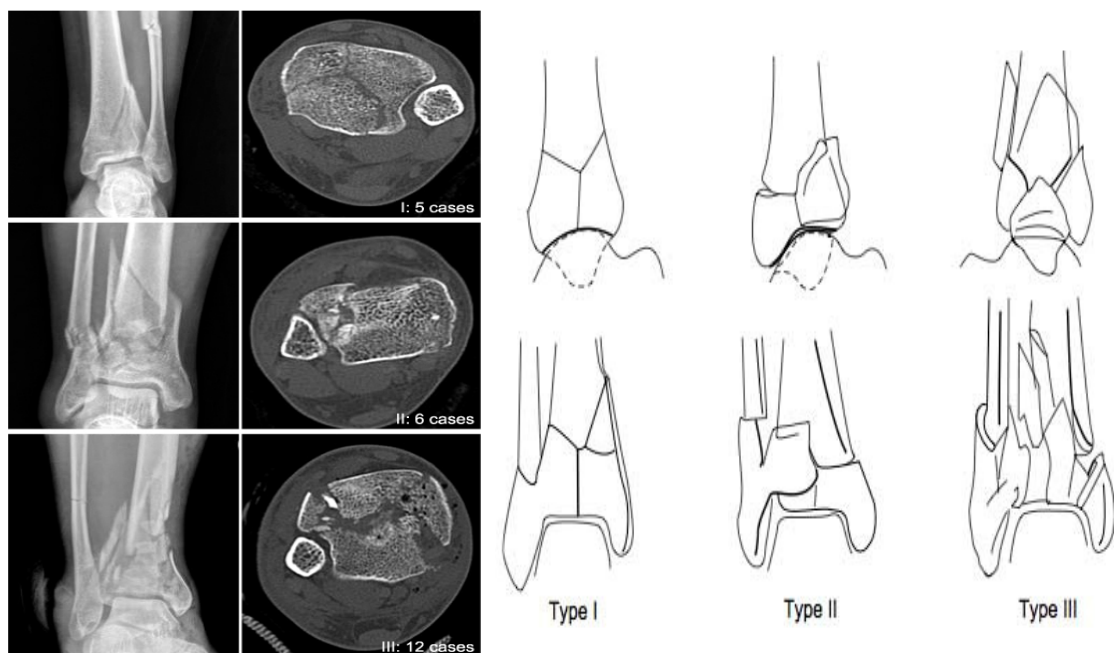
It has been the most commonly used classification .Its relevance today is minimal.

Prognosis correlates with increasing grades.

**Type 1:** Nondisplaced cleavage fracture of the ankle joint

**Type 2:** Displaced fracture of minimal impaction or comminution

**Type3:** Displaced fracture with significant articular comminution and metaphyseal impaction.



## **Classification of soft tissue injury (for open fractures):**

**(A) Gustilo and Anderson (1976)** <sup>[27]</sup>: In 1984 this system was modified, the modified classification is based on

The wound size,

Soft tissue damage muscle ligament and periosteal injury, periosteal stripping and Neurovascular injury.

- ❖ Type I – wound size <1 cm with no clean wound.
- ❖ Type II- wound size >1 cm without any severe soft tissue damage; no severe skin, laceration or avulsion.
- ❖ Type IIIA- wound size >1 cm with severe soft tissue .due to result of high velocity trauma but adequate skin coverage possible. Any segmental. Comminuted fracture even <1 cm or > 1 cm wound size included in this group
- ❖ Type IIB wound size >10 cm, high velocity trauma with loss of skin, skin coverage not possible but musculoskeletal unit can be repairable.
- ❖ Type III C- wound size >10 cm. musculoskeletal unit cannot be repairable. Any size of wound along with arterial injury, any

neurovascular damage regardless to wound size consider in this group.

- ❖ This classification has prognostic significance.

**(B) Tscherne and Gotzen Classification:** <sup>[28]</sup>

- ❖ Grade 1- absence or small contusion of skin , small laceration because of speculated fracture fragment from inside out.
- ❖ Grade 2 – moderate wound contamination, any type of contusion of soft tissue and skin, laceration of any type,
- ❖ Grade 3- high grade severe soft tissue loss , high grade of fracture comminution, severe contamination, any fracture which complicate as compartment syndrome and necrosis because of any neurovascular injury include in this grade.
- ❖ Grade 4- any sever soft tissue injury which resembles as subtotal and near total amputation, with injury of all important surgical anatomical contents which includes major blood vessels and nerves, results in total ischemic necrosis. Loss of more than  $\frac{1}{4}$  circumferential soft tissue losses of the extremities.

## **TSCHERNE classification for soft tissue injury in closed fracture<sup>[29]</sup>**

This classifies status of soft tissue in closed fracture and takes into account indirect versus direct injury mechanism.

**Grade 0-** indirect forces causes fracture without any significant soft tissue injury

**Grade 1-** closed fracture due to result of low or moderate velocity trauma

**Grade2-** closed fractures due to moderate to high velocity trauma with significant soft tissue injury, any deep contaminated contusion with abrasion of skin, fracture which are under high suspicion of development of compartment syndrome.

**Grade 3-** brutally crushed soft tissue with neurovascular injury , rupture of major blood vessels, degloving injury of subcutaneous tissues, avulsion injury to subcutaneous tissue, already developed compartment syndrome ,

## **MECHANISM OF INJURY<sup>[30]</sup>**

### **Direct Injury:**

These include five principal causes –

Self fall while walking,

Any indoor or outdoor sports injuries,

Direct impaction due to assault or heavy object blow,

Road traffic accidents while driving motor vehicle and

Gunshot injuries.

Falls may be simple like twisting ankle and fall injury, fall,

And fall from height. The highest incidence is seen in motor vehicle accidents usually affecting the motor cyclists, pedestrians and automobile occupants.

### **Axial loading injuries:**

Bone is an anatomical structure which follows the visco-elastic mechanics. According to visco-elastic mechanics if load increases continuously, it shifts the stress strain curve. If axial loading on bones

increases rapidly, bone absorbs all rapidly increasing axial forces and fails to compensate it and releases more energy. This released energy directly affects the surrounding soft tissue environment including muscle, tendons, joint articulation and results in injury. Usually injury is limited to the proximal to the joints in epiphyseal and metaphyseal region and can be involved diaphyseal region also.

Fracture types and patterns depend upon:

1. In which direction force is migrating
2. Limb position at the time of impact of forces.

# **METHOD OF EVALUATIONS AND PROCESS OF MANAGEMENT**

## **HISTORY**

A deep careful history of injury should be obtained first .It signify about the mechanics of injury, any other concomitant injury of nearby structures, general health and built of the patient and medical factors which can vary the healing of fracture, The mechanism of injury signifies about severity and grade of energy which was transmitted to bone and surrounding soft tissue environment at the time when the fracture was happening. Mechanics of injury also help to determine the fracture type and pattern so that planning and management becomes easy for the surgeon who ultimately affects the functional outcome and prognosis of fracture. IN case of compound injury status about surrounding atmosphere at the time of injury signifies to decide the antibiotic therapy.

## **PHYSICAL EXAMINATION**

Thorough clinical examination of the injured patient is mandatory. Patient should be stabilized hemodynamically first. Any intracranial, intrathorasic, intraabdominal, pelvic, spinal or any life

complicating injury should be ruled out .As the patient stabilized and cleared from any complicating events, injury of the ankle should be focused.. Initially ankle and foot injury appears clinically normal so should be careful while examining the injury. Vascular status of the ankle and foot should be assessed first. Any deformity of the ankle which hampering the vascularity of ankle and foot should be treated immediately .Any ankle dislocation compromising vascularity should be reduced immediately, any misalignment due to fracture affecting vascularity should be realigned manually. After alignment check the pulse and assessed the vascularity of ankle and foot. After reassessment of vascularity ankle and foot should be splinted to avoid unnecessary soft tissue injury.

Compound injury should be focused than, extent and size of the wound, grade of contamination, injury status of musculotendinous unit, any major injury to neurovascular unit should be reassessed. Thorough wound wash with 9 liters of normal saline and peroxide with betadine should be given immediately. IV antibiotics should be installed to the patient at regular interval.

IF the fracture is closed than next emphasis is on the skin status. Presence of severe swelling is contraindication of surgery. Limb should



be supported with splint; limb elevation should be done to reduce the swelling. Anti inflammatory drugs like serratopeptidase should be started to reduce the swelling and make the patient fit for surgery. Reassessment of skin status can be done only clinically with the wrinkle test. If the normal skin wrinkles appears on ankle and lateral aspect of foot with prominence of peroneal tendons at lateral malleoli confirms the subsidence of edema and patient can be operate.

Development of fracture boils is common and contraindication for surgery.

Fracture boils type:

1. Clear fluid filled fracture boils
2. Blood filled fracture boils.

Dermatologically both clear fluid and blood filled boils are formed due to division of dermo-epidural junction but blood filled boils are more dangerous because they signifies more deep soft tissue injury status. Second thing is if surgical incision made over the blood filled boil, causes more wound complication as wound dehiscence.

Presence of any ecchymosed or bruise warns about high grade injury of deep soft tissue injury.

Usually compartment syndrome has fewer incidences but should not be neglect. Status of tense compartment of foot and leg should be assessed. If compartment syndrome is confirmed urgent fasciotomy should be done and surgical fixation held up to wound healing. Those tibial plafond fractures which extent up to diaphyseal region has more chances of development of compartment syndrome.

## **RADIOGRAPHY**

Initially three routine X-rays should be taken immediately.

Antero-posterior view of injured ankle

Lateral view of injured ankle

Mortise view of injured ankle.

These standards X-ray of ankle provide whole information about fracture type and patterns. If fracture was tried initially to realign manually, repeat check x-ray should be obtain to asses the reduction. Repeat check x-ray helps surgeon to determine and decision making for surgical fixation procedures.

Study of x-rays decides about fractured bones, the plan of surgery, If associated bone with tibia like fibula below at distal 1/3 level, talus neck fracture, malleoli fractures, calcaneal fracture should be

operate simultaneously. X-ray of contra lateral ankle should be taken for anatomical consideration and for templating purposes.

CT scan of ankle advise to take if fracture is extending to the joint , pilon fracture with comminution. For this purpose Tri spiral radiography is more superior investigation in comparison of normal routine CT scan for articular fractures. It gives more important findings than simple x-rays and help surgeon to switch over other surgical methods.. Two-dimensional axial CT scanning helps to define the severity of the injury and aids with surgical planning.

## **METHODS OF TREATMENT**

### **CLOSED TREATMENT WITHOUT REDUCTION**

This method of fracture management is indicated only for undisplaced or mildly displaced A type fractures or type C1 fractures. First without reduction ankle should put on below knee slab and followed by cast conversion in next setting.. This method of treatment is strictly contraindicated in fracture of metaphyseal region with articular involvement because it requires prolonged immobilization in cast which cause ankle stiffness and restriction of range of motion and in future secondary osteoarthritis.

### **CALCANEAL PIN TRACTION**

Certain comminuted fracture of distal tibia may be treated with calcaneal pin traction for 3 to 4 weeks to maintain the alignment of fracture fragment. After 4<sup>th</sup> week pin traction removed and converted to below knee cast with non weight bearing.

Calcaneal pin traction also beneficial in those patient who are planned for surgical fixation but due to sever oedema, poor skin condition surgery has been delayed. This patient put on pin traction to maintain limb length and comminuted fragments in position.

## **TREATMENT IN MODE OF EXTERNAL FIXATION.<sup>[31]</sup>**

There are various type of external frames are available to construct the lower third tibial fracture. These frames stabilize the fracture of lower third region of tibia in term of external meaning.

.Examples of external frame are:

1. AO uni-planar external fixation devices
2. Ilizarov ring wire fixators,
3. Hybrid fixators which is the combination of pin and ring fixators..

Fracture fixation with external frames are accepted with high union rate from 74 to 81% with advantages of less wound infection in comparison to old conventional plating.

Old ankle spanning fixator usually result with healing with ankle stiffness and restricted ankle motion but recently derived ring, hybrid fixator does not have these complication as all component of these frames lies above the joint so early mobilization at joint can be started. Olive wires which are using to construct ring frames for lower third tibial fracture can use to reduce and stabilize fragment of articular regions.

Disadvantages of external frames.

1. Some severely comminuted distal tibial fracture cannot be reduced by meaning of external fixation.
2. Infection at pin insertion site, development of septic arthritis as secondary complication of pin and wires infection
3. Mal-alignment of the fracture, chances of non union, ankle stiffness are common with external frames.

## **OPEN REDUCTION AND INTERNAL FIXATION**

This modality of treatment is widely accepted now because of high union rates, early mobilization which prevents ankle stiffness, proper alignment of fracture by reducing it in direct vision, Initially in early era due to non availability of proper implants, poor antibiotics, ORIF was deferred due to high rates if infection and mal-alignment but at present due to availability of high sterile operating environment, higher antibiotics, advanced hardware's open reduction and internal fixation has been widely accepted.

## **OPEN REDUCTION AND INTERNAL FIXATION WITH LOCKING COMPRESSION PLATES:**

Locking compression plates are advanced generation implant which has the special bio-mechanics. Locking compression plate contains property of both internal and external fixation, . Locking compression devices provides rigid and stable anatomical construct due to threaded locking head screw. Locking head screw technology generates greater holding power because threaded head can be fix as a fixed angular stable construct. This fixed angular stable construct is independent from friction fitting. Surgical fixation with medial anatomical locking compression plating for lower third tibial fracture by open and MIPO technique yields fixed and stable anatomical limb alignment and superior functional outcome than other implants. . High rates of fracture union with early union, low reoperation rates and early return to routine activities are the main advantages.

## **RESULTS:**

Final result of lower third tibial fractures is excellent with surgical fixation. Tibial plafond high energy fractures result are not always good, it may be complication. If proper preoperative evaluation has been done than function outcome will be superior. Minor

complication as Superficial wound infection, ankle oedema , mild restriction can be avoided by proper follow up after surgical fixation.

If fracture has been managed by closed reduction chances of mal-alignment and time for union will be high.

If fracture has been managed by the meaning of external fixation, fracture will be healed with pin site complication. Healing time may be more and will be in term of frame removal.

If fracture has been managed by ORIF with locking compression plate, union will occur with superior range of alignment and with good functional out come.

.



## **COMPLICATIONS**

Complications of distal third and fourth leg bone fracture are:

### **A. Early complication:**

- a.** Compartment syndrome
- b.** Ligament injury
- c.** Fat embolism syndrome
- d.** Nerve injury
- e.** Infection and wound break down
- f.** Deep vein thrombosis

### **B. Late complication**

- a.** Mal union
- b.** Non union
- c.** Delay union
- d.** Ankle stiffness
- e.** Secondary osteoarthritis
- f.** Ankle instability
- g.** Ankle deformity

- i.** Varus
- ii.** Valgus
- h.** Persistent pain
- i.** Limp
- j.** Shortening
- k.** Aseptic necrosis
- l.** Persistent thrombophlebitis

## **LOCKING COMPRESSION PLATES<sup>[32]</sup>**

The important goal of any surgical procedure in orthopedics while fixing a fracture of bone is to achieve proper anatomical alignment of bone and to achieve its normal functioning.. There are main four principles of AO.

1. Anatomical reduction.
2. Rigid and stable fixation
3. Minimal soft tissue handling and maintain vascularity of soft tissue
4. Early mobilization of extremity to maintain joint functioning.

Principles of osteosynthesis by plating and screw technique have been already described. Clinical outcome and result will be improved if internal fixation has been achieved by both anatomical and biological fixation with fixed angular rigid stability. This purpose can be solved by Locking Compression Plating for lower third tibial fractures even in poor bone stock in osteoporotic bones.

The locking compression plate has been designed with features of both conventional plate and locking screw biomechanics. LCP is made of both stainless steel and titanium construct.

#### **A) Medial Anatomic contoured locking compression plate:**

The Locking Compression Plates (LCP) contains LC-DCP features:

- Fixation of screw with 80degree of longitudinal angulations range
- Fixation of screw with 14degree of transverse angulations range
- Spacing of holes with uniform arrangement
- each hole is a doubled combi hole in which compression hole in which screw in compression mode (load) and screw in neutral mode, both can be put easily .

A special design has been constructed for locking compression plate named as Combi holes. These combi holes contain both conventional compression holes with locking screw holes. In conventional compression hole both standard cortical screw and standard cancellous screw can be put. In threaded hole only specially

designed conical threaded screw can put which provide fixed angle stable anatomical construct between LCP and bone.

- A. specially designed conical threaded screw in threaded hole.
- B. standard cortical and standard cancellous screw in dynamic compression hole

### **B) Locking screws:**

The locking screw is a specially constructed design with special biomechanics rather than a standard 3.5mm cortical screw design to increase the stability of plate and bone anatomical construct, increase the rigidity of fixation and to make the surgical procedure easy.

#### **Specially designed characteristics of locking screw.**

***Threaded Conical shape screw head:*** this threaded conical head enhance the advancement of locking screw in the threaded plate hole and to provide a close fit fixed angled aligned screw plate construct.

***Large diameter of core of screw.:*** Specially designed large diameter of core helps screw to improve its bending characteristic and distribute the large core diameter improves bending and distributes and covers large area of bone.

**Shallow Thread profile:** because of large diameter of core of the screw, thread profile becomes shallow. Usually shallow thread profile is not acceptable in cortical screw but in case of locking screw shallow thread profile is acceptable because locking screw is not producing any compression effects by relaying thread hole in plate. Its head become locked in threads of hole and it provides stable construct of plate and screw instead of compression.

**Drive mechanism:**

Synthes locking screw has a special drive mechanism. Usually before inserting screw sleeve guide used to drill and make the path for locking screw. This star drive mechanism to locking screw provide improved torque transmission while inserting screw and it retains the screw even if holding sleeve guide has not been used.

**Unicortical screw fixation:**

Usually in standard plate and screw technique to increase the stability of plate and screw construct bicortical screw fixation is advisable .Bicortical screw fixation holds near cortex near to the plate and far cortex .But in locking screw designing unicortical screw fixation

itself solve this purpose because threaded hole locked in threaded hole and doesn't requires far cortex fixation for stable construct.

Due to threaded connection between locking screw and plate, stability and load transfer occurs at near cortex itself. Hence stability of screw with load transfer in locking screw designing occurs at screw head and near cortex in comparison of standard screw designing, stability and load transfer occurs at near cortex and far cortex due to bicortical purchase.

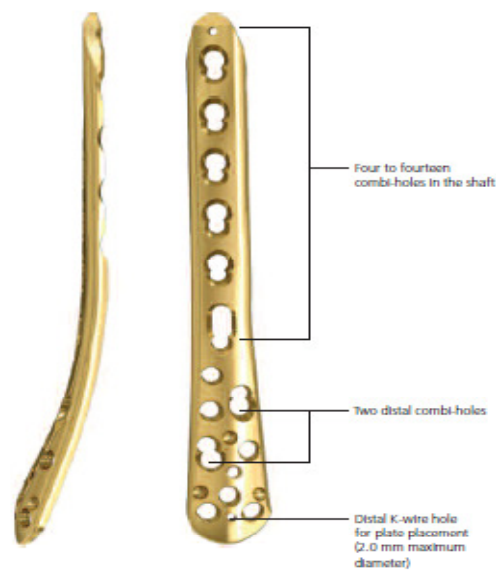
- A. To achieve stability in bicortical screw purchase, fixation should be at near and far cortex site
- B. To achieve stability in unicortical screw fixation, fixation should be between locking screw head and near cortex.

### **Plate features**

-Medial anatomical distal tibial locking compression plate used for surgical fixation.

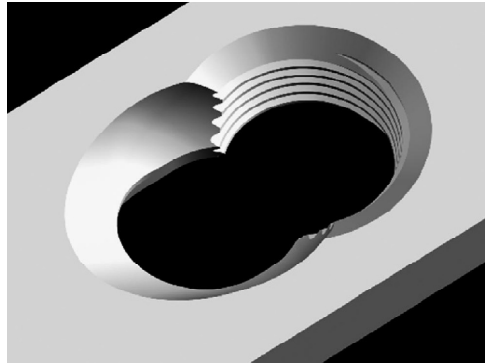
– Head of plate is low profile for minimal prominence on medial malleolus

- In combi holes for compression hole 3.5 mm cortical screw or 4mm cancellous can be use, for locking hole 3.5 and 4.9 mm locking screw construct available in plate.
- 3.5 mm cortex and 4.0 mm cancellous bone screws sit flush with plate in the non-locking portion of distal combi holes to minimize screw prominence
- Rounded edges to minimize soft tissue irritation





## Principles of locking compression plate:-



*Figure 1. combine principles of internal fixation and dynamic compression provided by locking compression plate*

LCP has been designed with two different anchor-aging technology in a single implant. In contrast these two different systems provide principle of internal fixation and dynamic compression both together which can be used by surgeon depending on the fracture and individual characteristic.

**Length of LCP**—correct length of LCP is a important factor for functional result. Unnecessary more length will harm the soft tissue and bone blood availability so proper length can reduce these unwanted factors.

In case of internal fixation plate should be applied in plate loading manner which mainly depends on plate length and screw placement, as low as possible. In case of ideal LCP application ideal LCP length

defined in term of plate spans width and plate screw density. Plate span length calculates by a quotient of plate length and fractured length. This quotient should be 2-3 for comminuted fractures and 8-10 for simple fractures.

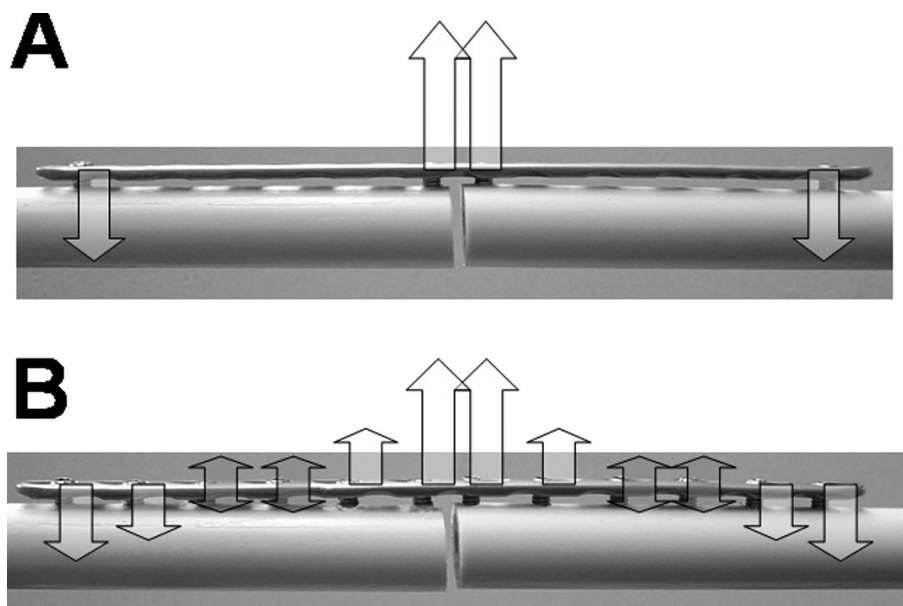
Screw density calculated by a quotient by screw inserted and screw holes in plate. (It should be 0.4-0.5). Two mono-cortical screws in each proximal and distal fragment are minimally required for a stable fixation. Bi-cortical screw fixation increase the interface between bone and plate so 1 bi-cortical screw minimally required in each proximal and distal fragment.

Axial pull out strength depends on the diameter of screw head . In 4.5 to 5mm mono-cortical locking screw 70% pull out strength has been provided compared to 100% strength in 4.5 conventional bi-cortical cortical screws.

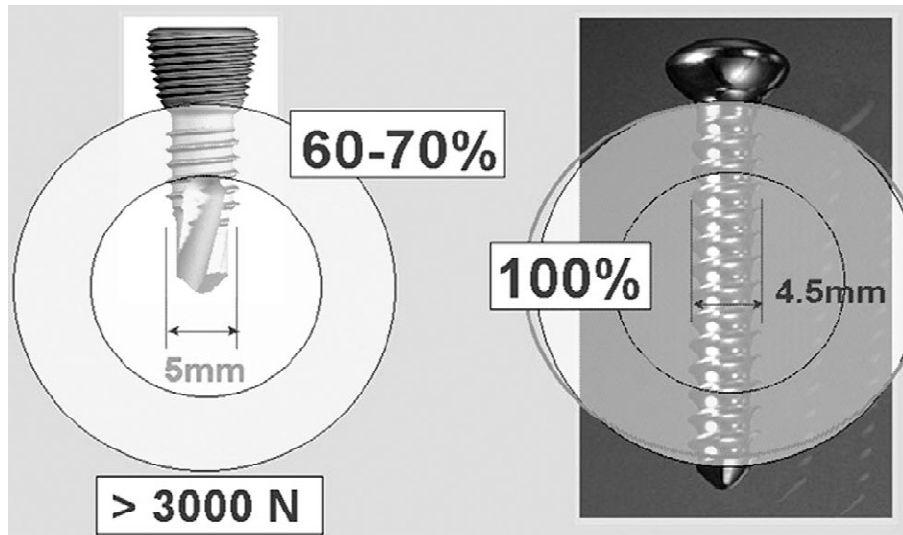
In simple fracture one or two combi holes near fracture space in each proximal and distal fragment should be left unused to reduce the stress on implant because more numbers of screw increase the stress on the implant as more load require to get bone contact.

In complex fracture with severe comminution and loss of bony contact between fragments, combi holes near fracture space in both proximal and distal fragment should be used always.

While drilling for screw ,aiming devices should be used always because any deviation  $> 5^\circ$  while drilling causes impaired stability because even small interval between bone and plate causes attenuation of leverage between plate and bone so appropriate length plate forms a stable axially rigid construct.



***Figure . Analysis of forces in dependence of the screw number shows different distribution of bending forces with minimal number of screws (A) and maximal number of screws (B).***



*Figure . Analysis of pull out forces reveals 70% holding force in a mono-cortical locking head screw (LHS) compared to a 100% of the holding force of a conventional bi-cortical 4.5 mm screw*

**Shape of locking compression plate;** while conventional plating compression required at fracture site because conventional plating works on compressive plate osteo-synthesis so correct adaptation of plate on bone is essential. In case of LCP, it works on bridging plate osteo-synthesis so correct adaptation is not so essential. Distal tibial medial anatomical LCP is pre contoured anatomical plate which cause proper seating on bone helps in achieving anatomical reduction and guides the locking screw in correct direction.

## **LCP characteristics.**

Limited-contact shaft profile

- Available in stainless steel or titanium

Combi-holes in the shaft and head accept the following:

- 3.5 mm cortex screws
- 4.9 mm locking screws
- 4.0 mm cancellous bone screws

Six round locking holes in the head accept the following:

- 3.5 mm cortex screws
- 3.5 mm locking screws
- 4.0 mm cancellous bone screws

## **ADVANTAGES OF LOCKING COMPRESSION PLATES**

It provides option for fracture management in both form of compression (both cortical and cancellous) as well as locking method.

- LCP is designed as a internal fixation hardware device which can be use as stable bridging construct over shattered and highly comminuted fractures.

- LCP maintains the vascularity of fracture fragment because of locking compression design, uni-cortical purchase of screw is enough to provide field stable construct so vascularity of far cortex intact. Due to locking of screw head in threaded hole close tight fitting of plate to bone is not necessary so periosteal vascularity is also intact
- Designing of locking to threaded hole of locking screw form a rigid fixed angle and axially stable construct which prevent screw pull out due to axial load transfer from plate to screw head. Toggling of screw, screw pullout, sliding and dislodgment is not occurs in LCP and prevents from loss of primary as well as secondary losses of reduction..
- Due to wide angulations range for screw fixation in threaded hole (80 degree longitudinal) screw can be put at various stable angles in metaphyseal region allow for fracture fixation which is not possible with other hardware's.
- LCP is highly advantageous in multiple complex comminuted fractures in which loss of medial and lateral buttressing. LCP provides better stable bridging construct for these types of fractures.
- Due to characteristic of fixed angled stability, LCP highly advantageous in metaphyseal fracture because in LCP mechanism

plate screw interface is important, plate bone interfacing is not so important.

- Locking compression plate provides fixation between plate and screw and anchoring of screw to the bone. So there is not so tight compression of plate or proper anatomical seating of plate requires for fixation. So this less contact between plate and bone preserves periosteal blood flow, Maintained bone perfusion decreases infection rate, bone resorption, delayed & non-union, & secondary loss of reduction.
- Better fixation in osteoporotic bone.
- Most of the fracture fix by bridging technique with elastic fixation, so less need of bone grafting & also because of angle stable constructs avoiding post operative collapse.
- Poor bone stock patients, osteoporotic patients, severely comminuted fracture where conventional screw purchase is not possible; LCP can be use in these circumstances

#### **DISADVANTAGES OF LOCKING COMPRESSION PLATES:**

- LCP is a specially designed hardware so before using it, its biomechanics should be clear to the operating surgeon.
- LCP has been designed to maintain and hold the fracture alignment so before applying and tightening of locking screw

proper reduction of fracture is required. As the screw tightened LCP position or replacement is not possible.

- LCP is pre designed hardware so any no need of correct seating of plate. Any attempt to contouring of LCP loses its mechanical property due to altered hole shape.



## **CRITERIA FOR SELECTION OF PATIENTS**

This study will include 20 patients having distal tibia fracture, presenting in Department of Orthopaedics in Stanley Medical College & Govt. Stanley Hospital, Chennai (Tamilnadu).

### **Inclusion criteria:**

1. Age >18years
2. All closed Fractures with intra-articular and extra-articular extension
3. Comminuted/Non-comminuted fracture of distal tibia
4. Open Gustillo type I

### **Exclusion criteria:**

1. Tibial shaft fractures
2. Elderly patients with co-morbid condition
3. Non weight bearing limb.
4. Open fracture with Gustillo type II

### **Causes of fractures:**

1. Road traffic accidents

2. Fall of heavy object
3. Self fall while walking

**Treatment protocol: - 5 stages**

- First aid
- Primary treatment
- Definitive treatment
- Treatment of complications
- Rehabilitation

On receiving the patient in casualty, a quick assessment of vital functions will be done and attempts would be made to stabilize the vital parameters. Associated head, chest and abdominal injuries will be managed with help of surgeons of respective specialty.

An incisive history regarding age, sex, mode of injury, time since injury and pre injury morbidity (if any) is to be taken.

A thorough clinical examination evaluating site of trauma with special consideration for any wounds, swelling, condition of proximal & distal joints, neurovascular status of the limb and a general examination assessing the general condition of the patient will be done.

Prophylactic doses of tetanus toxin and antibiotics are to be given. In open fractures wound washing with normal saline & hydrogen peroxide is to be done. X-Rays of the affected limb will be taken in at least 2 planes. The limb will be immobilized by AK slab.

After the first aid and preliminary treatment patient's routine investigations and anaesthetic workup will be done & patient will be posted for surgery as early as possible.

## OPERATIVE TECHNIQUE

### Procedure:

- ❖ Broad spectrum I.V. antibiotics are to be given immediate pre-operatively.
- ❖ Complete the preoperative radiographic assessment and prepare the preoperative plan. Determine plate length and instruments to be used.
- ❖ Position the patient supine on a radiolucent operating table under spinal or epidural anaesthesia.
- ❖ Locking Plate Osteo-synthesis is done with the Open and MIPO technique.

### Open technique :-

There are two methods to expose distal tibia for medial anatomical plate fixation by open technique.

- ❖ 1. **Anteromedial approach to tibia** <sup>[33]</sup>:- This approach is used for majority of comminuted distal tibia fracture and pilon fracture. This exposure is one of the most extensile distal

exposure available, allowing adequate visualization of a large percentage of the tibia plafond. It can be used in virtually all complete articular fracture patterns, and is especially useful in medial sided partial articular injury pattern. In particular, visualization and management of the central and medial aspect of the tibial plafond is facilitate, as well as simultaneous access to the medial malleoli, and the subcutaneous aspect of the distal metadiaphysis. The approach can be extended proximally to address proximal fracture extension into the diaphysis if needed. The obvious and main detractor from this exposure has been the reliance on the survival of a large antero-medial skin flap that may already be jeopardized from the injury. As a result, this exposure should only be performed through a viable soft tissue envelop by a surgeon experienced with the approach.

As described by the AO group and other the traditional antero-medial exposure begins approximately 1 cm lateral to the tibial crest and along the of the tendon of tibialis anterior. At the level of the ankle joint, the skin incision continues distally and medially, ending at the distal tip of the medial malleolus. The skin and subcutaneous tissue is elevated from the underlying deep fascia only to a point at which the medial aspect of the tibial anterior tendon is identified. Immediately

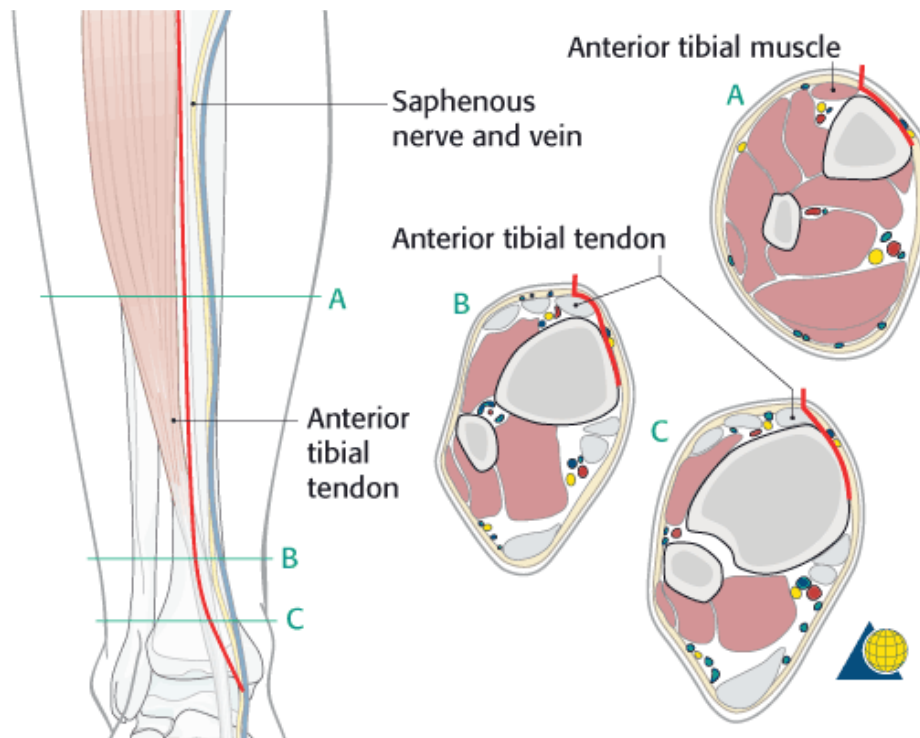
medial to the tibialis anterior tendon, a full thickness incision directly to the osseous surface of antero-medial distal is made. Ideally the deep dissection should not enter the tibialis anterior paratenon, but this may be unavoidable as the dissection approaches the articular surface as the periosteum begins to thin and the juxta-articular metaphyseal fracture lines are encountered. Once the deep periosteal layer deep incised, the antero-medial skin, subcutaneous tissue and periosteum are elevated as full thickness flap, akin to that performed during the extensile lateral exposure for calcaneal reduction and fixation. The anterior compartment is retracted laterally to allow limited visualization of the lateral column of distal tibia. The joint is entered by longitudinally incising the capsule in the location of the major fracture line.

**2. Modified antero medial approach to the tibia<sup>[34]</sup> :** A modification of antero-medial approach to tibia has been recently described by **Assal** that in association to allow visualization of the anterior and medial aspect of distal tibia , facilitates improved visualization of of the lateral distal tibial metaphysis and lateral articular surface. The main disadvantages to this approach are similar to that for the standard anteromedial approach. Additionally because of more acute angle is created at the level of ankle joint, the skin of the tip of the anteromedial flap may be more prone to necrosis.

Same like anteromedial approach incision starts from 1 cm lateral to the tibial crest and The longitudinal stem of incision extends up to tibio talar joint and angulated up to 105 to 110 degree medially. The horizontal stem of incision taken up to tip of medial malleoli taking care of saphaneous vien. . A full thick medial flap of skin subcutaneous tissue and periosteum retracted to medial side.

After exposure of fracture site appropriate size of medial anatomical locking compression plate put over the bone after proper anatomical reduction of fracture. As the distal tibial region has minimal blood supply, so unnecessary periosteal stripping should be avoided. For distal to fracture site LCP fixed with 3.5 mm locking screw system and for proximal to fracture site LCP fixed with 4.9mm locking screw system. As the fixation procedure over, thorough wound wash given. Wound closure done by allgower donati suturing and simple mattress fashion.

IF valgus instability suspected in some cases due to distal fibular fracture, fibular fracture fixed with 1/3 tubular plate by lateral approach to fibula to prevent valgus instability of ankle.

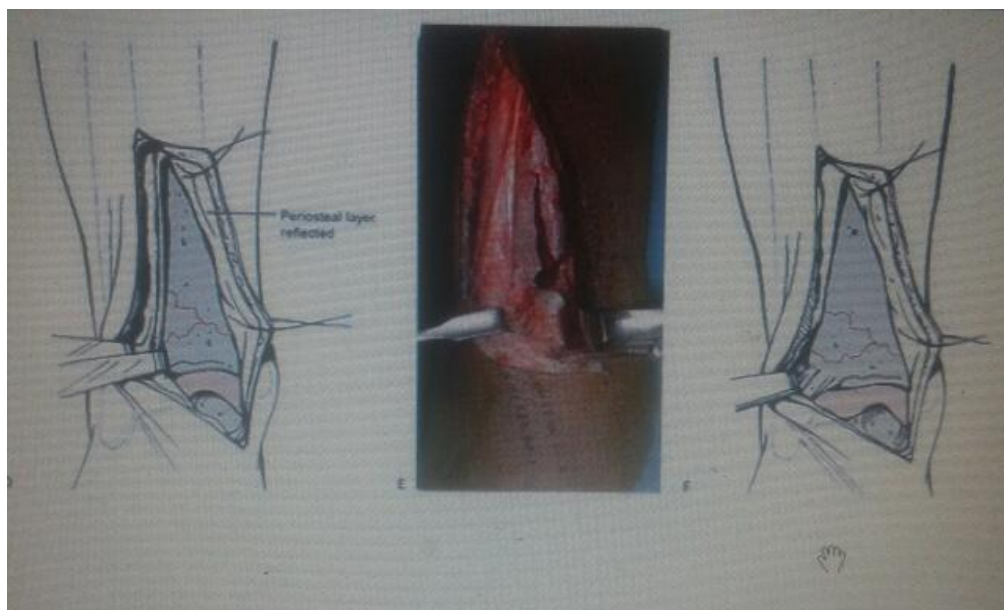


**Modified Anteromedial approach to distal tibia by  
Assal.....**



**Fig.B**

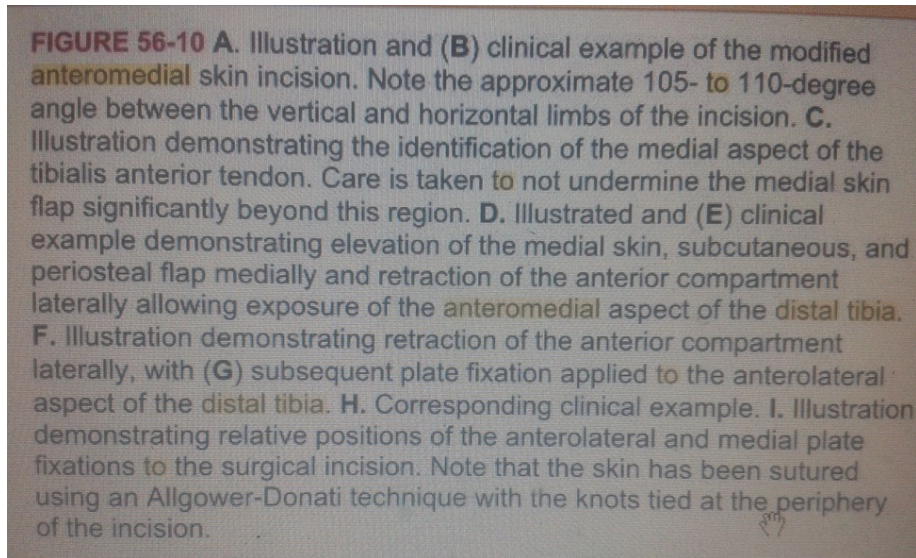




**Fig-C**



**Fig-D**



- ❖ **Minimal invasive technique** :-A smooth and gentle curved 5 cm incision given over the tip of medial malleoli ,with taking care of saphaneous vein to not to be cut .With the help of cobbs elevator a subcutaneous extraperiosteal tunnel prepare bridging over fracture and extending up to proximal region. An appropriate size of LCP selected and passes through this tunnel. Tip of proximal end of plate felt at proximal region and 3 cm incision given over to see correct placement of plate. Than under image intensifier fracture reduction done .Axial, rotation alignment of fracture confirmed under image intensifier. Distal locking screw put with 3.5mm system. and with maintained fracture reduction proximal locking screw put through proximal incision with 4.9mm locking screw system.

- ❖ If associated fibular fracture was found at lower third region at syndesmotic level or below syndesmotic level, it was fixed with 1/3 tubular plate. Fibular fracture fixation helps in indirect reduction of tibia and prevent from varus mal-alignment and additional stable fixation.
- ❖ After every surgical procedure before closure of the wound, thorough wound wash with normal saline has been given and after wound closure limb immobilized with below knee slab.

#### **Post-operative management:**

- ❖ Static quadriceps exercises & toe movements, as tolerated began from 1<sup>st</sup> post-op. day.
- ❖ Ankle mobilization is started from 3<sup>rd</sup> post-op. day. Intra-venous antibiotics are given for 5 days followed by a course of oral antibiotics for 7 days. Analgesics are to be given as per need. Suture removal is done on 10<sup>th</sup> post-op. day.
- ❖ Non weight bearing started with walker after 4<sup>th</sup> week.
- ❖ Partial protected weight bearing started as the first sign of callus seen in follow up x-rays. Usually after 8 to 10 week.

- ❖ X-rays will be taken at regular intervals and evaluated for fracture healing, alignment at fracture site & look for any evidence of mal-alignment.
- ❖ Full weight bearing started as the union achieved in 3 of 4 cortices, usually around 18 to 20 weeks. Clinically union is defined as painless fracture site during full weight bearing. Radiographically fracture will be considered united if 3 of 4 cortices in 2 radiographic views are continuous.

**Follow-up:** Patients will be followed up for a period of 6 month

1<sup>st</sup> follow-up: at 4th weeks

2<sup>nd</sup> follow-up: at 8th weeks

3<sup>rd</sup> follow-up: at 12<sup>th</sup> week

4<sup>th</sup> follow-up: at 6 months

At the final follow up patients will be evaluated using American Orthopaedic foot and ankle society (AOFAS) score.

## **AMERICAN ORTHOPAEDIC FOOT AND ANKLE SOCIETY SCORE. <sup>[35]</sup>**

Hind foot scale (100 points)

### **Pain (40 point)**

- |    |                           |      |
|----|---------------------------|------|
| 1. | No pain                   | - 40 |
| 2. | Occasionally mild pain    | - 30 |
| 3. | Daily moderately pain     | - 20 |
| 4. | Almost always severe pain | - 00 |

### **Function ( 50 points)**

#### **Limitation of activity**

- |    |   |      |
|----|---|------|
| 1. | No support, no limitation of activity       | - 10 |
| 2. | No support, no limitation of daily activity | - 07 |

but Limitation of recreational activity

- |    |  |      |
|----|--|------|
| 3. | Daily and recreational both activity limitation  | - 04 |
| 4. | Daily and recreational activity severely limited | -00  |

and support required in form of wheel chair, crutches, braces

### **Walking distance on blocks**

- |    |                       |     |
|----|-----------------------|-----|
| 1. | Greater than 6 blocks | -05 |
| 2. | 4 to 6 blocks         | -04 |
| 3. | 1 to 3                | -02 |
| 4. | 1 or less             | -00 |

### **Walking surface**

- |    |  |     |
|----|--|-----|
| 1. | No difficulty on any surface                                 | -05 |
| 2. | Some difficulty on stairs, uneven surface, ladders           | -03 |
| 3. | Severe difficulty on ladders, incline surface, uneven stairs | -00 |

### **Gait abnormality**

- |    |            |     |
|----|------------|-----|
| 1. | No or mild | -08 |
| 2. | Obvious    | -04 |
| 3. | Marked     | -00 |

### **Sagittal motion (flexion plus extension)**

- |  |     |
|--|-----|
| Normal or mild restriction (30* or more) | -08 |
| Moderate restriction (15* - 29*)         | -04 |
| Severe restriction (less than 15*)       | -00 |

**Hind foot motion ( inversion plus eversion)**

Normal or mild restriction (75%-100%)	-06
Moderate restriction (25 to 74%)	-03
Severe restriction (less than 25%)	-00

**Ankle hind foot stability ( antero-posterior, valgus, varus)**

Stable	-08
Definitely unstable	-00

**Alignment (10 point)**

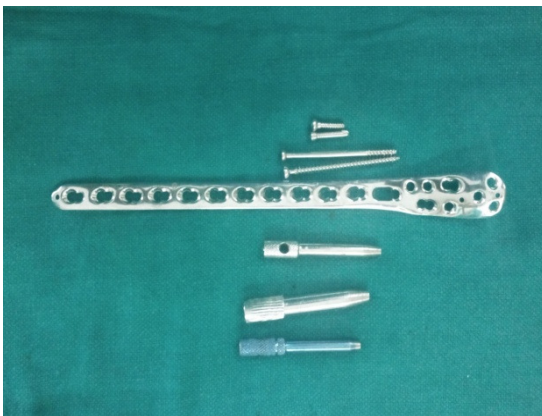
Good, plantigrade foot, mid foot well alignment	-10
Fair, plantigrade foot , some depress of mid foot mal-alignment	-08
Observed, no symptoms	
Poor, non plantigrade foot, severe mal-alignment symptoms	-00

**Total            100**

- 85            - excellent
- 70 to 80    -good
- 55 to 65    -fair
- < 50        -poor



## INSTRUMENTS:





## **INTRA OPERATIVE PICTURES**

**Open surgical method by anteromedial approach.**



### **Incision**



### **Exposure and reduction**



**Seating of plate**



**After Fixation**



**Skin closure with drain.**



## **Minimal invasive technique for Distal Tibial LCP-**

### **MIPPO (Minimally invasive percutaneous plate osteo synthesis)**



MINIMAL SKIN INCISION



EXPOSURE



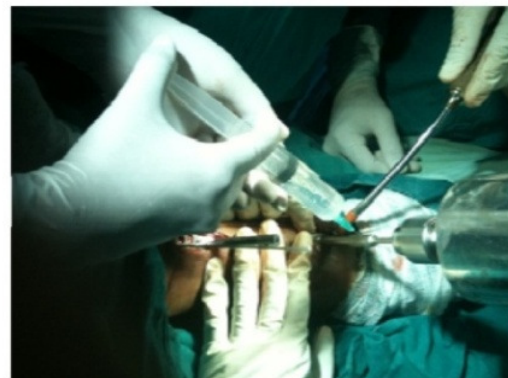
PLATE INSERTION WITH DISTAL  
K- WIRE FIXATON OF PLATE



PROXIMAL K-WIRE FIXATON  
WITH MINIMAL INCISION



DISTAL SCREW FIXATION



PROXIMAL SCREW FIXATION OF  
PLATE WITH MINIMAL INCISION



**COMPLETE SKIN CLOSURE**

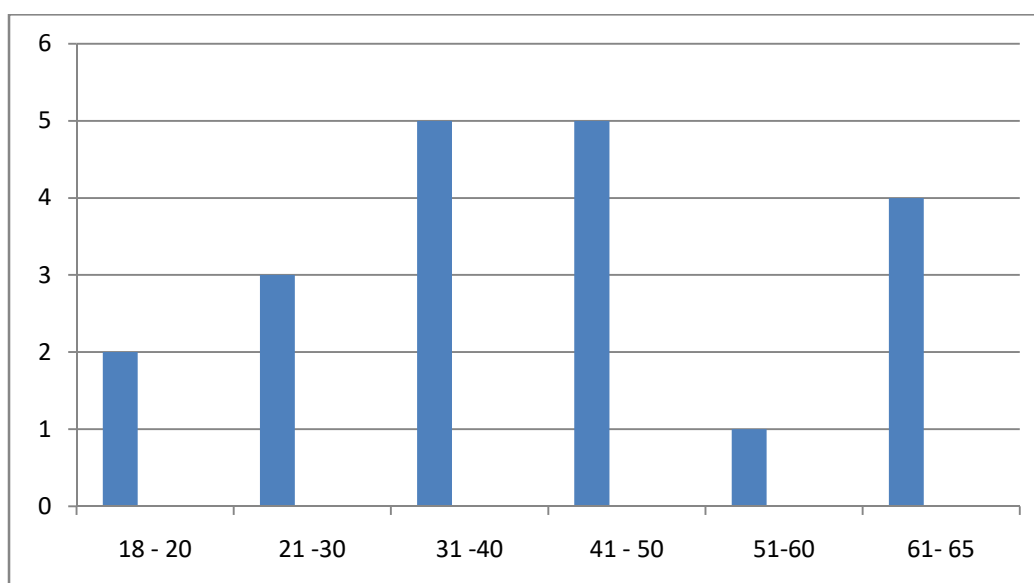
## OBSERVATION AND RESULTS

Primary aim of treatment of fracture is sound clinical and radiological union with no functional disability or residual deformity. In this series a total of 20 patients have been studied. All the cases were fixed using locking compression plate. The study period was from January. 2013 to July 2014.

### AGE DISTRIBUTION

The age of the patient ranged from 18 to 65 years with the fracture being most common in 4<sup>th</sup> and 5th decade of life.

Age group	No of patient	Percentage
18- 20	2	10
21-30	3	15
31-40	5	25
41-50	5	25
51-60	1	5
61-65	4	20

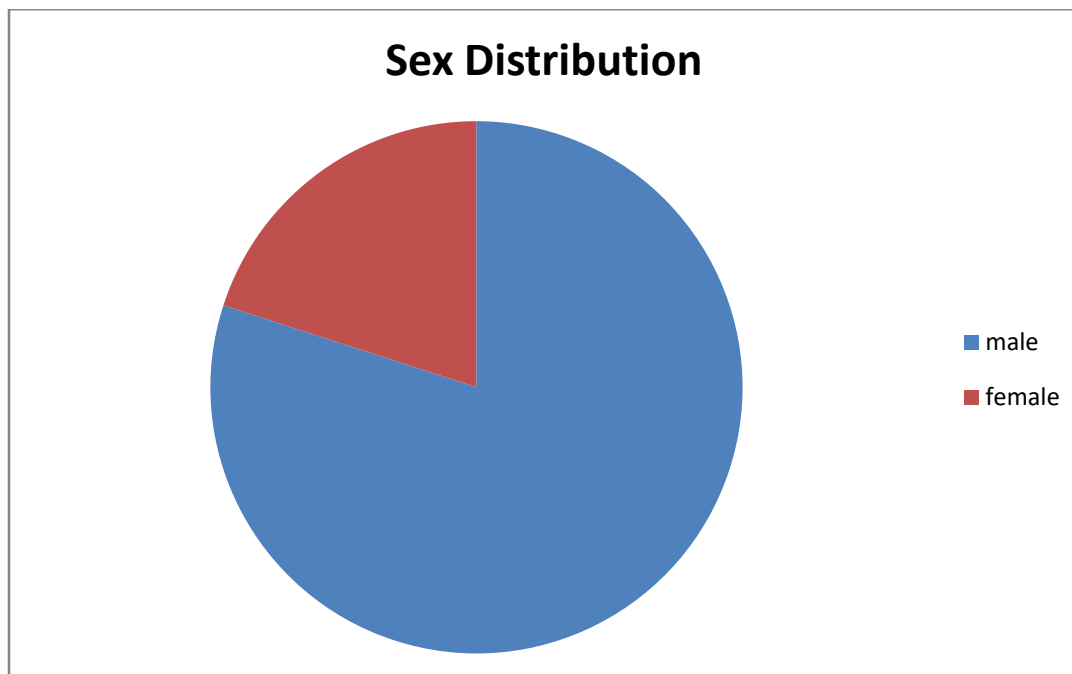


## SEX DISTRIBUTION

Out of 20 patients, 16 (80%) patients were males and 4 (20%) patients were females showing male predominance because of traveling and working in fields and factories

**Table 2: Sex Distribution**

Sex	No. of patients	Percentage
Male	16	80
Female	4	20

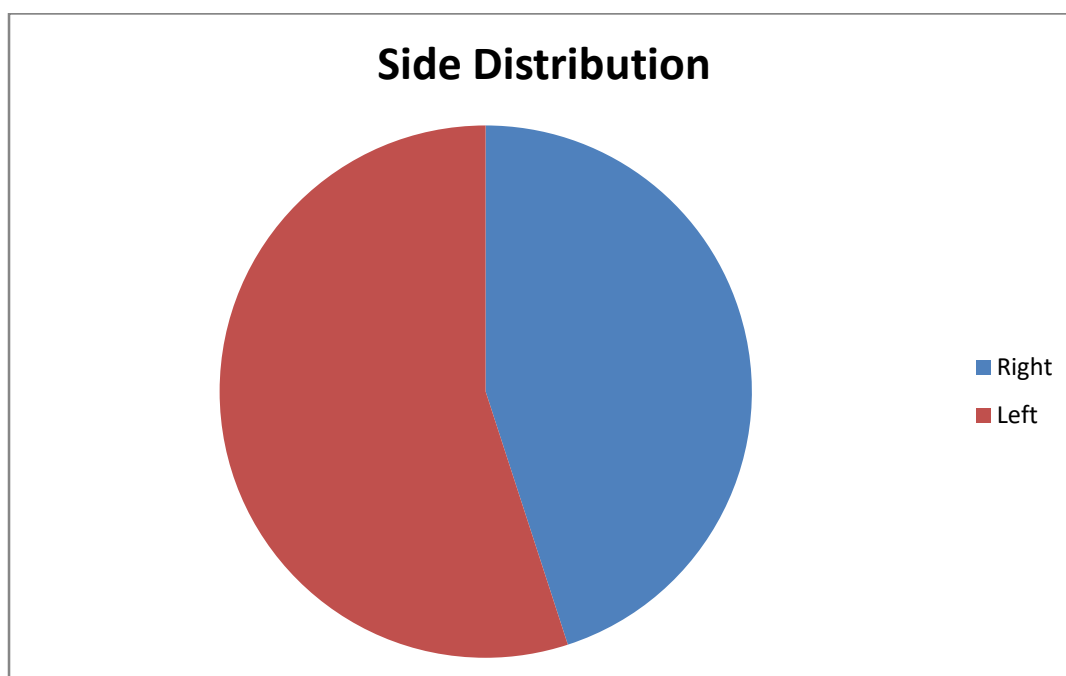


## DISTRIBUTION ACCORDING TO THE SIDE OF INJURY

There were 9(45%) patients with right distal tibia fracture and 11 (55%) patients with left distal tibia fractures.

**Table 3: Side Affected**

Side	No. of patients	Percentage
Right	9	45
Left	11	55

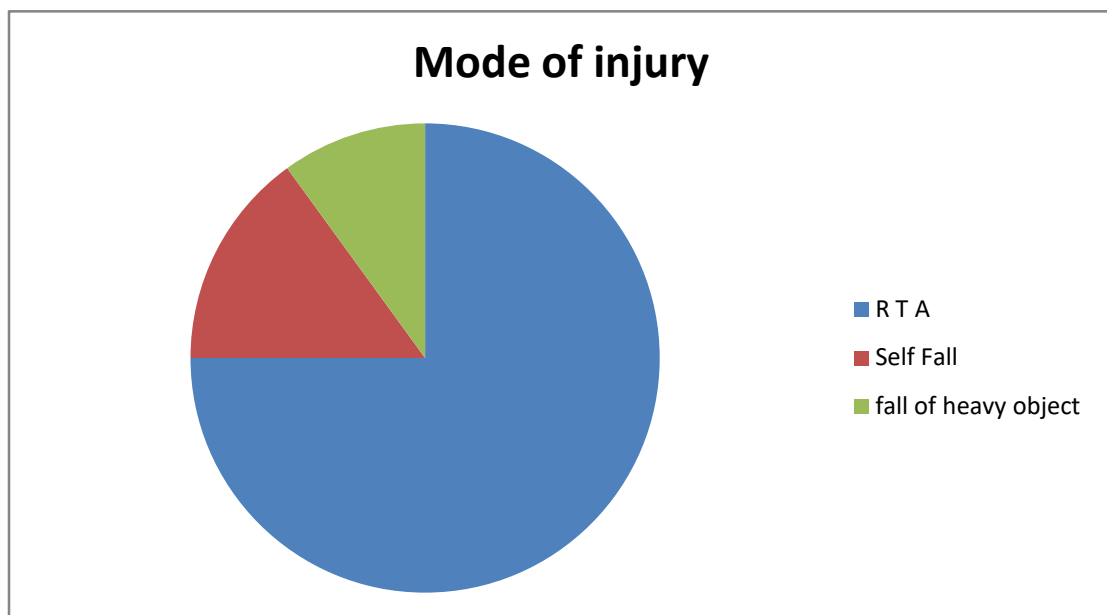


## DISTRIBUTION ACCORDING TO MODE OF INJURY

In our study, 15 (75%) of patients sustained injury following road traffic accidents and 3(15%) patients sustained injury following fall , 2 (10%) patients fall of heavy object.

**Table 4: Mode of Injury**

Mode	No. of patient	Percentage
Road traffic accident (RTA) (High energy)	15	75
Accidentally self fall while walking	3	15
Fall of heavy object	2	10
Total	20	100





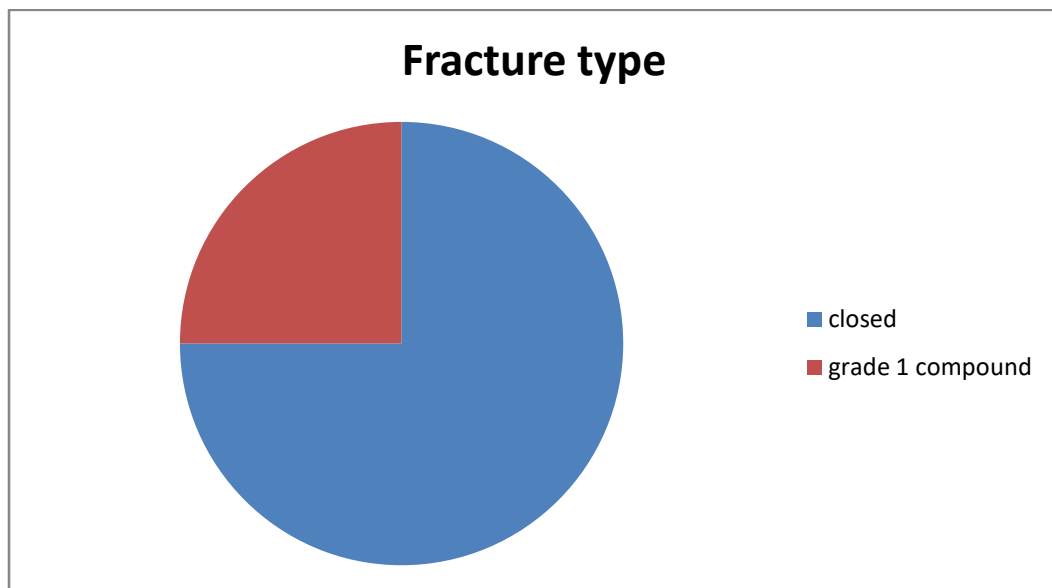
## Fracture characteristic:

### 1. Clinical type of fracture:

Out of 20 cases, 15 (75%) cases were closed fractures and 5(25%) cases were open fractures

**Table 5: Clinical type of fracture**

Clinical Type	No. of patients	Percentage
Closed	15	75
Compound		
a. Open grade I	5	25
b. Open grade II	-	-
c. Open grade III	-	-

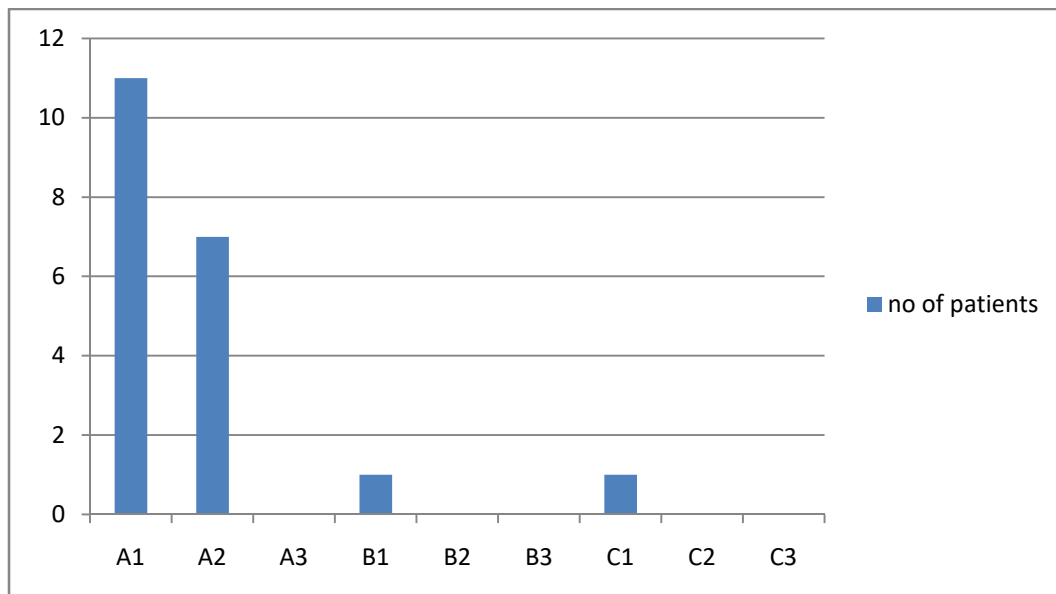


## 2. Fracture pattern:

The fracture pattern was classified based on AO-OTA system

**Table 6: Fracture pattern**

A.O. Classification	No. of patients	Percentage
A <sub>1</sub>	11	55
A <sub>2</sub>	7	35
A <sub>3</sub>	-	-
B <sub>1</sub>	1	5
B <sub>2</sub>	-	-
B <sub>3</sub>	-	-
C <sub>1</sub>	1	5
C <sub>2</sub>	-	-
C <sub>3</sub>	-	-



**Associated Injuries:**

16 of 20 cases studied had an associated fracture of the lower third of fibula. 1 patient had fracture radius on the same side. 3 patients had head injury. Among 16 associated lower third fibula fracture 6 patient underwent for fibula fixation.

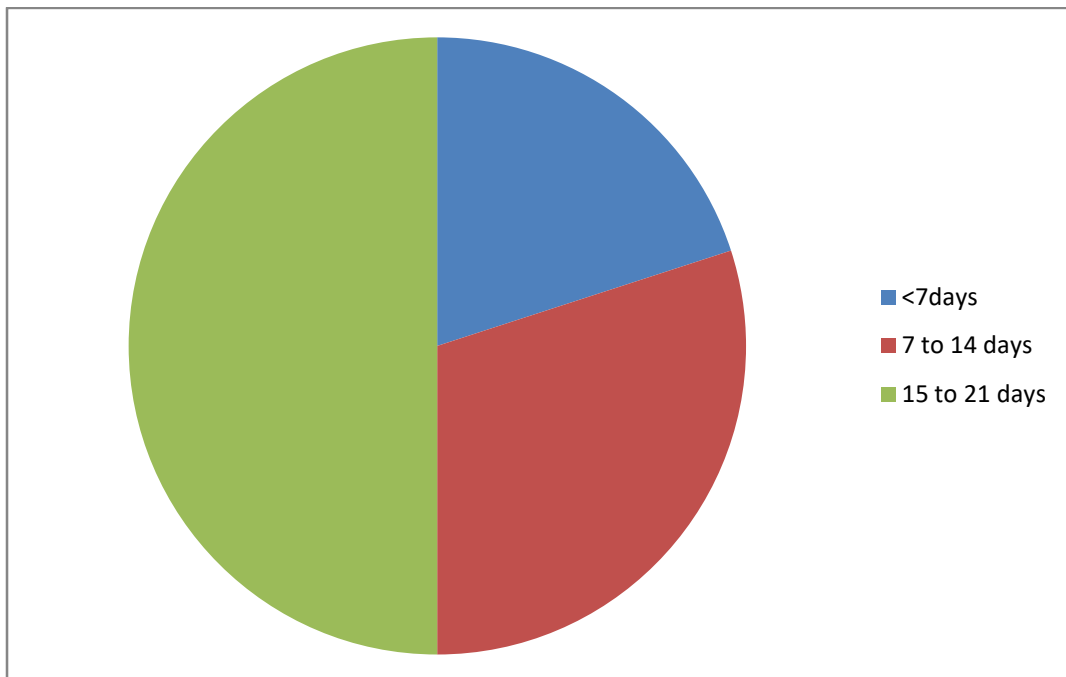
**Statistics of Surgery:**

All the 20 cases were operated under Lumbar Sub Arachnoids block (Spinal anesthesia). Among 20, 11 cases studied underwent open reduction and internal fixation with MIPO techniques with help of fluoroscopic control too. 9 cases where reduction was difficult to achieve operated with open reduction internal fixation with modified antero-medial approach. Follow up ranged from 4 to 6 months.

## DURATION BETWEEN INJURY AND OPERATION

**Table 8: Duration between injury and operation**

<b>Duration between injury and operation</b>	<b>No. of patients</b>	<b>Percentage among operated patients</b>
<7 day	4	20
7 to 14 days	6	30
15 to 21 days	10	50
>21 days	0	0

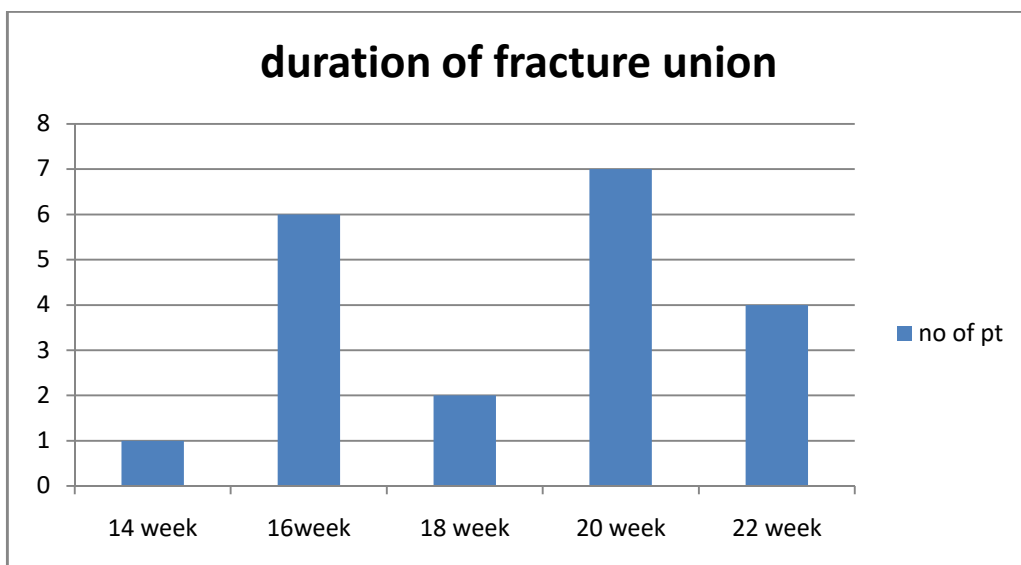


### Duration of fracture Union:

All the fractures united with an average of 18.7 weeks. 11 cases operated by MIPPO with LCP and fracture united an average 18.36 weeks. 9 cases operated with open reduction LCP and fracture united an average 19.11 weeks.

**Table 9: Duration of Fracture Union**

Time (weeks)	No. of patients	Percentage
14 <sup>th</sup> week	1	5
16 <sup>th</sup> week	6	30
17 <sup>th</sup> week	-	-
18 <sup>th</sup> week	2	10
19 <sup>th</sup> week	—	—
20 <sup>th</sup> week	7	35
21 <sup>th</sup> week	—	—
22 <sup>nd</sup> week	4	20



## FUNCTIONAL RESULTS

At the final follow up patients were evaluated using American Orthopaedic foot and ankle society (AOFAS) score and patients were categorized in:

> 85            =      Excellent

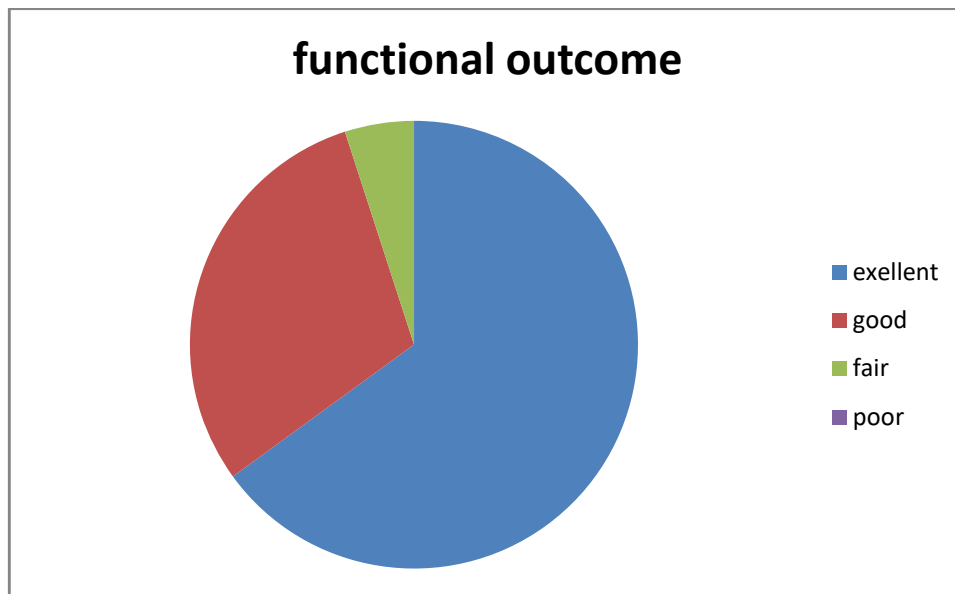
70-80           =      Good

55-65           =      Fair

<50             =      Poor

**Table 10: Functional results**

<b>Results</b>	<b>No. of patients</b>	<b>Percentage</b>
Excellent	13	65%
Good	6	30%
Fair	1	5%
Poor	0	0



**Complication:**

**Intra operative complication:** There were no cases of intra-operative complications.

**Post operative complication:**

**1. Superficial skin infections:**

Three patient developed superficial skin infections were treated with daily dressings and appropriate antibiotics after pus culture and sensitivity. All these infections subsided on the above said treatment

**2. Deep infection:**

There was no case of deep infection.

### 3. Ankle stiffness:

We had 6 patients with mild restriction ankle (>50% ROM ankle). This was probably due to the incompletion of the patients to the advised physiotherapy regimen as there was no mean to monitor the physiotherapy of the ankle joint after discharge of the patient.

### 4. Minimal ankle oedema:

There were two cases of ankle oedema and treated by compression elastic bandage, serratiopeptidase, chymoral forte drugs.

Complications	No. of Patients	Percentage
Superficial skin infection	3	15
Deep Infection	0	0
<b>Ankle movement restriction</b>		
Normal or Mild restriction < 25%	6	30
Moderate restriction 25 – 75 %	0	0
Severe restriction >75 %	0	0
Valgus angulations < 5*	1	5
Ankle edema	2	10



## DISCUSSION

Fractures of distal tibia are among the most difficult fractures to treat effectively. The status of the soft tissues, the degree of comminution and sustained at the time of injury affect the long term clinical results. The goal of operative treatment is to obtain anatomic realignment of the joint surface while providing enough stability to allow early motion. This should be accomplished using techniques that minimize osseous and soft tissue de-vascularization in the hopes of decreasing the complications resulting from treatment.

The present study was under taken to determine the efficacy of the locking compression plates in treatment of the fractures of the distal tibial metaphysis.

We evaluated our results and compared them with those obtained by various other studies utilizing different modalities of treatment, our analysis is as follows:

### **Age Distribution:**

Our study revealed the average age of patients with such injuries to be 41.35years (18 to 65). It is comparable with a study on similar fractures conducted by below authors.

<b>Study</b>	<b>Min Age</b>	<b>Max Age</b>	<b>Average</b>
Cory Collinge et al <sup>[18]</sup>	17	62	43
Heather A Vallier et al <sup>[20]</sup>	16	77	39.1
Shrestha D et al <sup>[23]</sup>	20	65	38.75
Present Study	18	65	41.35

### **Sex Distribution:**

In our study, the male preponderance for such kind of injuries were high 80% compared to the study by Cory collinge 77% ,Andrew Grose et al<sup>[49]</sup> ,and Heather A Vallier et al<sup>[36]</sup> which was 67% and 69 % possibly due to the fact of male dominance over the female in traveling, occupational injures etc., in India

<b>Study</b>	<b>Male Percentage</b>	<b>Female Percentage</b>
Cory collinge et al <sup>[18]</sup>	77	23
Andrew Grose et <sup>[36]</sup>	67	33
Heather A Vallier et al <sup>[20]</sup>	69	31
Shrestha D et al <sup>[23]</sup>	60	40
Present study	80	20

### **Mechanism of Injury:**

Cory Collinge et al<sup>[18]</sup> observed 100% high energy fractures in his study. Andrew Grose et al<sup>[36]</sup> could attribute only 58% of such injuries to be of high energy.

However, our present study correlates with the study conducted by Cory Collinge et al<sup>[18]</sup>, Andrew Grose et al<sup>[36]</sup>, and along with that Heather A. Vallier et al<sup>[20]</sup>, who contributed only 51% of high energy fractures.

<b>Study</b>	<b>Mode of injury</b>	
	<b>High Energy (RTA, Fall from height)</b>	<b>Low Energy (Assault, Simple Fall, sporting injuries etc)</b>
Cory collinge et al <sup>[18]</sup>	100%	0%
Andrew Grose et al <sup>[36]</sup>	58%	42%
Heather A Vallier et al <sup>[20]</sup>	51%	49%
Shrestha D et al <sup>[23]</sup>	50%	50%
Present study	75%	25%

### **Clinical type Percentage:**

Our study had 25% open injuries and 75% closed fractures. This was comparable on the studies conducted by Heather A Vallier et al<sup>[20]</sup> who has 30% open fractures, Hazarika et al<sup>[12]</sup> who has 40% open fractures.

<b>Study</b>	<b>Open Fracture</b>	<b>Closed Fracture</b>
Heather A Vallier et al <sup>[20]</sup>	30	70
Hazarika et al <sup>[12]</sup>	40	60
Present study	25	75

### **Fracture Patterns Percentage:**

The present study had comparable results to other studies A study by Cory collinge et al<sup>[18]</sup> showed 16% CI, 32% C2 and 24% C3. Andrew Grose et al<sup>[36]</sup> also had fractures types 2% B1, 4% B2, 12% B3, 6% C1, 12% C2, 64% C3. Heather A Vallier et al<sup>[36]</sup> also had fractures 31% A, 21% B, and 44% C.

<b>Study</b>	<b>A1</b>	<b>A2</b>	<b>A3</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>C1</b>	<b>C2</b>	<b>C3</b>
Cory collinge et al <sup>[18]</sup>	9	9	10	-	-	-	16	32	24
Andrew Grose et al <sup>[36]</sup>	5	5	7	2	4	6	6	12	64
Heather A Vallier et al <sup>[20]</sup>	31	-	-	21	-	-	44	-	-
Shrestha D et al <sup>[23]</sup>	12	4	2	2	-	-	-	-	-
Present Study	55	35	-	5	-	-	5	-	-

### **Duration of fracture union:**

The average time for fracture union in various studies conducted using various methods was 16-28 weeks. Our study had an average fracture union of 18.7. With MIPPO procedure union rate was 18.36 weeks and with open reduction union rate was 19.11 weeks which were comparable with studies conducted using the locking compression plates. Cory Collinge et al<sup>[18]</sup> had an average fracture union of 21 weeks and Abid Mushtaq et al<sup>[37]</sup> had an average of 22 weeks.

<b>Study</b>	<b>Method</b>	<b>Average Fracture Union</b>
Cory collinge et al <sup>[18]</sup>	MIPO	21 weeks
Abid mushtaq et al <sup>[37]</sup>	MIPO	22 weeks
Im GI, et al <sup>[11]</sup>	ORIF	20 weeks
Hazarika et al <sup>[12]</sup>	MIPO	19.3 weeks
Shrestha D et al <sup>[23]</sup>	MIPO	18.5 weeks
Present Study	MIPO	18.36 weeks
	ORIF	19.11 weeks

### **Results and Complications:**

In a study that established open reduction with plate and screw fixation as the standard. Ruedi and Allgower<sup>[4]</sup> achieved 74% acceptable results in 84 patients. These results did not deteriorate for 9 years.

Mast et al<sup>[38]</sup> reported 78% satisfactory results in 37 patients with a minimum follow up interval of 6 months. Less dramatic results were reported by a variety of authors when the plafond fractures studied included larger numbers of high energy injuries.

Bourne and colleagues<sup>[6]</sup> studied 42 patients with tibial plafond fractures, 62% of whom were victims of high-energy trauma. Of the 16 Ruedi type III fractures treated by open reduction and internal fixation, only 44% had a satisfactory result. The majority of these fractures were complicated by nonunion (25%), infection (13%), and Arthrodesis (32%).

Ovadia and Beals<sup>[7]</sup> reviewed 34 fractures equivalent to Ruedi Type III treated with traditional open reduction and plate fixation. Good to excellent results were achieved in only 47%. Complications were numerous and, although not sub classified according to fracture type, superficial infections or skin loss developed in 9 patients (11%), osteomyelitis developed in 5 patients (6%), 17 patients (12%) required either ankle Arthrodesis or Arthroplasty.

Teeny and Wiss<sup>[39]</sup> studied 60 tibial plafond fractures. 60% of those were secondary to high-energy trauma. They reported 50% poor results when open reduction and plate fixation was used. When the subset of 30 Ruedi Type III fractures was analyzed there were 12(40%)

acceptable outcomes with 37% of these fractures complicated by a skin slough or deep infection.

Mc Ferranet al<sup>[40]</sup> reported on 52 tibial plafond fractures treated with open reduction and internal fixation. Forty percent of these were 84 Ruedi Type III injuries. Overall, 40% of the patients suffered some complication, with a deep infection or osteomyelitis occurring in 43% of fractures, and a wound breakdown requiring soft tissue coverage in 62% of fractures.

<b>Study</b>	<b>Methods</b>	<b>Acceptable</b>	<b>Not Acceptable</b>
Ruedi and Allgower <sup>[4]</sup>	Open Reduction and internal fixation	74	26
Mast et al <sup>[38]</sup>		78	22
Bourne et al <sup>[6]</sup>		44	56
Teeny and Wiss <sup>[39]</sup>		50	50
Im GI et al <sup>[11]</sup>	Open reduction & internal fixation with anatomic plates	88	12
Gao et al <sup>[41]</sup>	MIPO	87	13
Hazarika et al <sup>[12]</sup>		87	13
Ozkaya U. et al <sup>[14]</sup>		81	19
Present study	ORIF and MIPPO both	95	5
	MIPO	100	-
	ORIF	89	11

NB: The excellent and good results have been tabulated as acceptable and the fair and poor results as not acceptable for easier comprehension.

Im GI et al<sup>[11]</sup>, in a study of 30 patients using anatomic plates and screws, open reduction and internal fixation was done with 88.2% excellent to good results according to Oleurd and mollander function ankle score and with a better alignment of fracture fragments.

Hazarika et al<sup>[12]</sup>, a series of 20 patient of distal tibial fracture treated using locking compression plates through MIPPO technique. This approach aims to pressure bone biology and minimize surgical soft tissue trauma. This provided 85 87.5% of good to excellent results. Fractures were classified according to the AO system and performed as scored stage surgery after sterilization with external fixators primarily.

Gao et al<sup>[41]</sup>, studied 32 adult patients with very short metaphyseal fragments in fractures of distal treated with a polyaxial locking system. The polyaxial locking system shown results of 87.3 functions out come with American Orthopaedic Foot and Ankle Society score which offer more fixation versatility, may be a reasonable treatment option for distal tibia fracture with very short metaphyseal segments.

Ozkaya U et al<sup>[14]</sup>, a retrospective review of 22 patients with distal third tibial fractures were treated with titanium locking compression plates using minimally invasive technique good biological fixation of



distal tibial. A total of 81% of good to excellent outcome was assessed using American Orthopaedic Foot and Ankle Society.

Study	Fracture type	Outcome
Collinge et al. <sup>[18]</sup>	26	Ankle stiffness ;2 Malunion ( $\geq 5^\circ$ deformity) : 1 Secondary procedure: 3
Hasenboehler et al. <sup>[42]</sup>	32	Nonunion: 2 No malunion ( $\geq 5^\circ$ deformity or $\geq 1$ cm LLD) Plate bending ( $18^\circ$ ): 1 Pseudoarthrosis: 2
Hazarika et al. <sup>[12]</sup>	20	Nonunion: 2 Delayed wound break down: 2 Wound infection: 1 Implant failure: 1 Secondary procedure: 2
Ronga et al. <sup>[43]</sup>	19	Nonunion:1 No malunion ( $\geq 7^\circ$ deformity or $\geq 1$ cm LLD) Deep infection:3
Bahari S et al. <sup>[19]</sup>	42	No malunion Superficial wound infection: 2 Deep infection: 1 Implant failure: 1
Mushtaq A et al. <sup>[37]</sup>	21	Delayed union: 1 Non union :1 Wound infection: 2 Secondary procedure: 2
Lau TW et al. <sup>[22]</sup>	48	Delayed union: 5 Wound infection: 8 Secondary procedure:1

Gupta RK et al. <sup>[44]</sup>	80	Delayed union :7 Non union: 3 Malunion ( $\geq 5^\circ$ deformity or $\geq 1$ cm LLD): 2 Wound infection:1 Wound breakdown: 2 Secondary procedure: 2
Shrestha D et al [23]	20	Delayed union :1 No malunion ( $\geq 5^\circ$ deformity or $\geq 1$ cm LLD) Superficial wound infection: 2 Deep infection: 1 Secondary procedure: 1
Present Study	20	Superficial skin infection 3 Deep Infection 0 Mild Ankle stiffness 6 (< 25% rom restriction) Valgus angulations 1 Ankle oedema 2

# CLINICAL PHOTOGRAPHS

## CASE -1



Pre operative



Post operative



Union

## Range of motion



Clinical dorsiflexion



Clinical plantarflexion

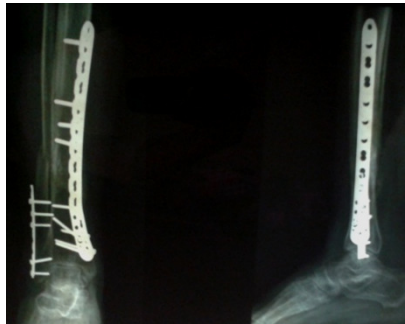
## CASE 2



**Pre op**



**post op**



**Union**

**Range of motion**



**Clinical plantarflexion**



**Clinical dorsiflexion**

### **CASE 3**



**Pre op**



**Post op**



**Union**

### **Range of motion**



**Clinical dorsiflexion**



**Clinical plantarflexion**

## CASE 4



**Pre op**



**Post op**



**Union**

## Range of motion



**Dorsiflexion**



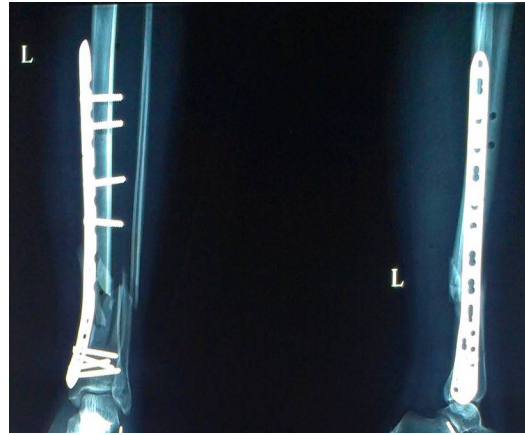
**Plantarflexion**



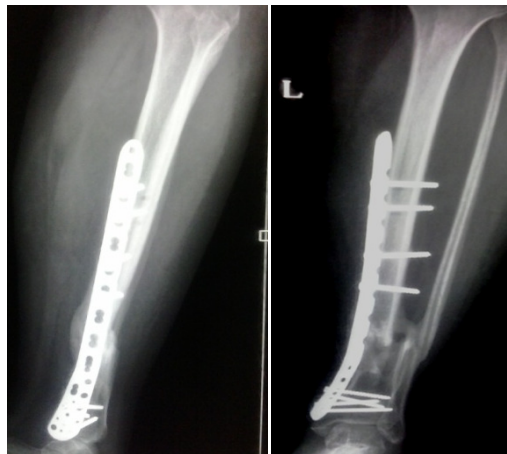
## CASE 5



**Pre op**



**Post op**



**Union**

**Range of motion**



**Dorsi-flexion**



**Plantar-flexion**

## CONCLUSION

In the present study, 20 patients with fractures of the distal third and fourth tibia had undergone reduction and internal fixation with distal tibia locking plating through open and MIPO technique.

This technique has resulted in the effective stabilization of these fractures. It does provide adequate stability and allows early motion. The distal tibia locking plating through open and MIPO technique not only helps in achieving reduction in difficult situations, but also in rapid union, because it facilitates preservation of the blood supply to the fragment and anatomical reduction of the fracture.

The greatest advantage of reduction and internal fixation with distal tibial locking plate is that anatomical reduction is achieved and fracture hematoma is not disturbed much. It is also effective in extra articular fractures occurring within 5cm of the joint because, intramedullary nails often do not provide enough stability and external fixators usually applied for primary stabilization and until soft tissue edema get subsided and delays the return to work with fixators.

It is a simple, rapid and straight forward procedure which has a reduced surgical time in both extra articular fractures and intra articular



fractures due to newer anatomically contoured locking compression plates for the distal fourth tibial fractures.

Although, a larger sample of patients and longer follow up are required to fully evaluate this method of treatment, we strongly encourage its consideration in the treatment of such complex fractures.

## SUMMARY

In this study, 20 cases with twenty fractures of lower third fractures of tibia in adults were surgically managed by reduction and internal fixation with both open reduction and minimally invasive plate osteo-synthesis (MIPO) using distal tibial medial anatomical locking compression plate between January 2013 to July 2014 at Stanley medical college % Govt Stanley hospital, Chennai

- All patients were evaluated clinically and radio-logically before and following surgery, for an average period of follow up was 6 months.
- The age of the patient in this study, ranged from 18 years to 65 years average being 41 years.
- There were 16 male patients as compared to 4 female patients in this study.
- 11 patients had fracture of left lower one third of tibial fractures and 9 patients had fracture of right tibia.
- 15 fractures were closed and 5 were open fractures.

- 15 cases sustained fracture following road traffic accident (high energy trauma), 5 cases sustained fractures following self fall while walking and fall of heavy object (low energy trauma).
- There were 16 cases of associated fibular fractures.
- The fractures were united in all patients with average 18.7 week duration for union.
- The fractures were additionally supported by a below knee plaster of paris slab postoperatively for 10 days. Protected weight bearing was allowed only once signs of progress toward union are evident, usually at 6 weeks postoperatively. Partial weight bearing started at 8 to 12 week, depending on the radiographic signs of fracture healing.
- Post-operatively, 3 patient developed superficial skin infection, 6 patients developed mild ankle stiffness, 2 patient developed minimal ankle oedema, due to loss of post operative protocol.
- Good amount range of mobility of ankle joint was present in almost all patients.
- By the analysis of the data collected in the present study, reduction and internal fixation with Distal Tibial medial

anatomical locking compression plate by Open and MIPO technique for distal third and fourth fractures of tibia is one of the acceptable forms of treatment in Lower third including distal third and distal fourth tibial fracture with or without comminution.

## REFERENCES

1. Böhler L (1931) Diagnosis, pathology and treatment of fractures of the os calcis. J Bone Joint Surg 13:75–89
2. Lambotte 1913, Edavelaire 1937, Trojen 1956. Positive management of the main tibial fracture and first description of the distal fourth tibia intra articular fractures by albino lambotte. Orthopaedic case Text Book. SOA.
3. Gay and Evrard (Gay 1963) were the first to advocate the operative stabilization of the entire distal tibial fracture. Orthopaedic care text book, SOA.
4. Ruedi TP, Allgower M. The operative treatment of intra articular fractures of the lower end of tibia. Clin Orthop 1979; 138: 105-110.
5. Kellam J, Waddell JP. Fractures of the distal tibial metaphysis with intra-articular extension - the distal tibial explosion fracture. J Trauma 1979; 19: 593-601.
6. Bourne R, Rorabeck C, Macnab J. Intra-articular fractures of the distal tibia: The pilon fracture. J Trauma 1983; 23: 591-596.

7. Ovadia DN, Beals RK (1986) Fractures of the tibial plafond. J Bone Joint Surg Am 68(4):543–551
8. Dillin L, Slabaugh P. Delayed wound healing, infection, and non union following open reduction and internal fixation of tibial plafond fractures. J Trauma 1986; 26: 1116-1119
9. Wyrsh B, McFerran MA, McAndrews M, Limbird TJ, Harper MC, Johnson KP et al. Operative treatment of fractures of the tibia plafond: 91 A randomized, prospective study. J Bone Joint Surg Am 1996; 78: 1646-1657
10. Helfet D, Paul Y S, David L, Joseph B Jr. Minimally invasive plate osteo-synthesis of distal fracture of tibia. Injury 1998;28:S42- S48
11. Im GI, Tae SK. Distal metaphyseal fractures of tibia: a prospective randomized trial of closed reduction and intramedullary nail versus open reduction and plate and screws fixation. J Trauma. 2005 Nov;59(5):1219-23;discussion 1223.
12. Hazarika S, Chakravarthy J, Cooper J. Minimally invasive locking plate osteosynthesis for fractures of the distal tibia – Injury.2006 Sep;37(9):877-87.Epub 2006 Aug 8.

13. Gao H ,Zhang CQ, Luo CF, Zhou ZB, Zeng BF. Fractures of the distal tibia treated with polyaxial locking plating. Clin Orthop Relat Res.2009Mar;467(3):831-7.Epub 2008 Aug22
14. Ozakaya U, Parmaksizoglu AS, Gul M, Sokuou S, Kabukcuoglu Y. Minimally invasive treatment of distal tibial fractures with locking and non locking plates. Foot Ankle Int .2009 Dec;30(12):1161-7
15. Ahmad MA, Sivaraman A, Zia A, Rai A, Patel AD. Percutaneous locking plates for fractures of the distal tibia: Our experience and a review of the literature. J Trauma 2010
16. Leonidou, G. Erturan, A. Brooks, S. Deo. Tibia-a single centre study of the managementof73patients. <http://www.eexot.gr/userfiles/congresses/68/papers/0%20001.pdf>
17. R. Schouten, A Vincent. Percutaneous plating of distal fractures. J Bone joint Surg Br 20111 vol. 93 B no. SUPP III 376
18. Collinge C, Protzman R. Outcomes of minimally invasive plate osteosynthesis for metaphyseal distal tibia fractures. J Orthop Trauma 2010, 24:24–29.

19. Bahari S, Lenehan B, Khan H, Mcelwain JP. Minimally invasive percutaneous plate fixation of distal tibia fractures. *Acta Orthop Belg* 2007, 73:635-640.
20. Vallier HA, Le TT, Bedi A (2008) Radiographic and clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond): plating versus intramedullary nailing. *J Orthop Trauma*; 22(5):307–311.
21. Cheng W, Li Y, Manyi W. Comparison study of two surgical options for distal tibia fracture-minimally invasive plate osteosynthesis vs. open reduction and internal fixation. *Inter Orthop* 2010, doi: 10.1007/ s00264-010-1052-2
22. Lau TW, Leung F, Chan CF, Chow SP. Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. *Inter Orthop* 2008, 32:697-703.
23. Shrestha D, Acharya BM, Shrestha PM. Minimally invasive plate osteosynthesis with locking compression plate for distal diaphyseal tibia fracture. *Kathmandu Univ Med J* 2011;34(2)62-8



24. Henry Gray (1821-1865): Anatomy of the human body 11. Osteology – 37<sup>th</sup> Edition.
25. Fracture and dislocation compendium: Orthopaedic Trauma Association committee for coding and classification. J Orthop Trauma 1996 Suppl 1 iv-ix-154.
26. REudi and allgower classification for tibial pilon fracture , Kenneth and Kovel fourth edition page no 493
27. Gustilo RB: The fracture classification manual. St Louis 1991, Mosby
28. Tscherne HG, Gotzen L. Fractures with soft tissue injuries: Berlin : springer –verlag, 1984.
29. Tscherne HG, Gotzen classification for soft tissue injury in closed fracture , Kenneth and Kovel fourth edition page no 30
30. JL Marsh and Charles L Saltzman. "Ankle fractures". Robert W. Bucholz, James D Heckman in Rockwood and Green's fractures in Adults, 5th edition, Philadelphia, Lippincott, Williams and Wilkins, 2001: 2051

31. Griffiths GP, Thoradson DB. Tibial plafond fractures limited internal fixation and a hybrid external fixator. Foot Ankle Int 1996; 17: 444-448
32. Principles and Clinical Application of the Locking Compression Plate (LCP) NIEMEYER, N. P. SÜDKAMP Department of Orthopaedic Surgery and Traumatology Freiburg University Hospital, Freiburg i. Br., Germany
33. Anteromedial approaches to distal tibia , Rockwood and green 7<sup>th</sup> edition page no 1940
34. Modified anteromedial approaches to distal tibia by ASSAL , Rockwood and green 7<sup>th</sup> edition page no 1940
35. AOFAS SCORE , GLENN AND PFEFFER foot and ankle surgery page no .678
36. Andrew Grose, Michael. J. Garden. Open reduction and internal fixation of tibial pilon fractures using a lateral approach. J. Orhop Trauma 2007;21:530-537
37. Abid Mustaq, Rizwan Shahid, Muhammad Asif, Mohammad Maqsood. Distal tibial fracture fixation with locking

- compression plate(LCP) using minimally invasive percutaneous osteosynthesis (MIPO) technique. Eur J Trauma Emerg Surg2008
38. Mast JW, Spiegel PG, Pappas JN. Fractures of tibial pilon. Clin Orthop 1988; 230: 68-82
  39. Teeny S, Wiss DA, Hathaway R. Tibial plafond fractures, errors, complication and pitfalls in operative treatment. Orthop Trans 1990; 14: 265.
  40. McFerran MA, Smith SW, Bonlas HJ. Complications encountered in the treatment of pilon fractures. J Orthop Trauma 1992; 6: 195-200.
  41. Guo JJ, Tang N, Yang HL, Tang TS. A prospective, randomized trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J Bone Joint Surg Br.2010 Jul;92(7): 984-8
  42. Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. *Injury* 2007, 38:365– 70.

43. Ronga M, Longo UG, Maffulli N. Minimally invasive locked plating of distal tibia fractures is safe and effective. *Clin Orthop Relat Res* 2010, 468:975–82.
44. Gupta RK, Rohilla RK, Sangwan K, Singh V, Walia S. Locking plate fixation in distal metaphyseal tibial fractures: series of 79 patients. *Inter Orthop* 2010, 34:1285.

S. No.	Name	Age (yrs)	Sex	Occupation	I.P No	Mode of Injury	Side	Duration between Injury & Surgery (days)	Classification fracture (A.O.)	Type of fracture open / close	Anaesthesia	Modality of Treatment	Partial wt. bearing with crutches (wks)	Full wt. bearings	Union time (wks)	Complications	ROM			Pain	Function	Alignment	Total score	Result
																	Knee	Ankle	Subtalar					
1	Ameer basha	18	M	Student	39461	RTA	Lt	7 days	A1	CL	S.A.	Plating with mippo	8	16	16	Nil	N	>75%	>75%	40	47	10	97	Excellent
2	Gandhi	33	M	Businessmen	54833	fall of heavy object	Lt	15 days	A2	CL	S.A.	Open reduction and plating	10	18	16	superficial wound infection	N	>75%	>75%	40	47	10	97	Excellent
3	Devadanam	36	M	Labourer	29847	fall of heavy object	Rt	10 days	A2	CL	S.A.	Plating with mippo	10	16	20	Nil	N	>75%	>75%	30	41	8	79	Good
4	Antony	46	M	Businessmen	25489	RTA	Lt	14 days	A2	CL	SA	Open reduction and Plating	12	18	20	Nil	N	>75%	>75%	40	46	10	96	Excellent
5	Govindsamy	42	M	Labourer	20217	RTA	Lt	20 days	A1	OG1	SA	Open reduction and Plating	14	20	22	Ankle oedema	N	>50%	>50%	20	31	8	59	Fair
6	Jannath	34	F	Housewife	26583	RTA	Lt	7 days	A2	CL	SA	Plating with mippo	10	16	20	Nil	N	>75%	>75%	40	46	10	96	Excellent
7	Anbu	35/	M	Businessmen	1E+06	RTA	Lt	14 days	C1	CL	SA	Open reduction and Plating	10	18	20	Minimal oedema 5° valgus	N	>50%	>50%	30	34	8	72	Good
8	Govindan	65	M	Labourer	28774	RTA	Rt	5 days	A1	CL	SA	Plating with mippo	10	16	16	Nil	N	>75%	>75%	40	41	8	89	Excellent
9	Prakash	18	M	Student	43868	Self fall at home	Lt	7 days	A1	CL	SA	Open reduction and Plating	8	14	14	Nil	N	>75%	>75%	40	47	10	97	Excellent
10	Rajendran	62	M	Labourer	1E+06	RTA	Rt	16 days	A1	CL	SA	Plating with mippo	10	14	20	Nil	N	>75%	>75%	30	46	10	86	Excellent
11	Malliga	30	F	Housewife	32410	Self fall at home	Rt	10 days	A2	CL	SA	Plating with mippo	8	14	16	Nil	N	>75%	>75%	40	42	10	92	Excellent
12	Sarweshawaran	44	M	Businessmen	1E+06	RTA	Lt	17 days	A1	CL	SA	Plating with mippo	12	16	22	Minimal ankle oedema	N	>50%	>50%	40	37	10	87	Excellent
13	Thirupal	40	M	Bussinessman	27676	Self fall at home	Rt	15days	A1	CL	SA	Plating with mippo	8	14	18	Nil	N	>75	>75	40	43	10	93	Excellent
14	Varalakshmi	64	F	Housewife	14151	RTA	Rt	21 days	B1	CL	SA	Open reduction and Plating	10	16	16	superficial wound infection	N	>50	>50	30	37	8	75	Good
15	Sundaramoorthy	55	M	Farmer	25328	RTA	Lt	10 day	A1	OG1	SA	Plating with mippo	10	14	18	Nil	N	>75	>75	40	47	10	97	excellent
16	Saravanan	45	M	Shopkeeper	1E+06	RTA	Rt	20 days	A2	CL	SA	Open reduction and Plating	12	16	22	NIL	N	>50	>50	30	37	8	75	good
17	Logan	48	M	factory worker	22936	RTA	Lt	17 day	A2	OG1	S.A.	Plating with mippo	8	16	16	Nil	N	>50	>75	30	38	10	78	good
18	Lakshmi	65	F	Housewife	52163	RTA	Rt	20 days	A1	OG1	SA	Open reduction and plating	12	18	22	superficial wound infection	N	>50	>50	30	37	10	77	good
19	Velan	26	M	Bussinessman	14370	RTA	Rt	10 days	A1	CL	SA	Plating with mippo	8	14	20	NIL	N	>75	>75	40	47	10	97	excellent
20	MahendrN	21	M	Student	22879	RTA	Lt	16days	A1	OG1	SA	Open reduction and plating	10	18	20	NIL	N	>75	>75	40	44	10	94	Excellent